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TITLE: Testing Soviet Economic Policies, 1928-1940

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TESTING SOVIET ECONOMIC POLICIES, 1928-1940

Holland Hunter and Everett J. Rutan, III

Executive Summary, September 1980

The USSR is thought by most of the world to have been transformed from a backward agricultural country into a powerful industrial state during the last fifty years. Impatient nationalist leaders in the Third World may decide that by imitating Soviet methods they can achieve similar results. But this project provides evidence that Soviet methods--especially the forced collectivization of agriculture--were in fact tragically inefficient. The pre-war economic growth potential of the economy was undermined through unnecessary policy errors that imposed measurable costs on the whole economy.

The Soviet regime expected collectivized agriculture to provide a surplus which could be used to build heavy industry. Simultaneously, farming could be modernized. Instead, fierce peasant resistance caused a drastic shrinkage in available animal draft power; investment had to be shifted away from industry in order to provide tractors, combines and trucks as replacements. Agricultural output fell, the surplus disappeared and the whole economy suffered. While these facts have long been understood in the West, this project provides the first quantitative estimates of the costs involved.

Our procedure involves fitting early Soviet data--not yet disturbed by Stalinist pressures--into an input-output (national balances) framework of ten producing sectors and six categories of final demand. We establish a baseline for the year 1928, and derive the parameters that Gosplan apparently perceived as governing the economy's ability to

expand. The data are used to build a dynamic linear programming model called KAPROST (from "kapitalnyi rost" or capital growth in Russian). The solution to this model provides a complete set of national accounts over six two-year time periods which shows how the economy might have grown from 1929 through 1940 under "problem-free" conditions. The economic potential inherent in a growing labor force combined with a growing stock of fixed capital is thus revealed.

We then modify this problem-free reference solution by altering relevant parameters to reflect several developments--depression, rearmament, collectivization--that were not foreseen by Gosplan. The resulting composite reconstruction produces an expansion path that appears to match up quite closely with the actual historical record as pieced together by Western students of the period. The differences between the problem-free reference solution and the composite reconstruction can be attributed to specific events and policies, and rough estimates of the size of individual impacts can be derived.

The Soviet economy, as modeled by KAPROST in the problem-free solution, undertakes substantial investment in fixed capital while undergoing structural transformation and introducing new technology. Production rises quite rapidly after 1928. By 1940 gross output is almost four times as large as in the base year, and GNP proper is more than four times as large as it was in 1928. Agricultural output doubles; industry and construction produce eight times as much; services output rises by a factor of 2.7. Moreover, this is accomplished without any belt tightening: consumption never falls below 1928 levels, and by 1940 is over two and one-half times as large.

These are extremely high rates of growth, perhaps implausibly high. They reflect optimistic assumptions concerning all the technical parameters governing production and capital formation, though none of the individual

parameters lies outside the bounds observable in other times and places. Japan's record a quarter of a century later lends credence to the possibility of expansion on this scale. It is surely reasonable, then, to take our reference solution as indicating the upper limits of hypothetically achievable growth.

In adjusting this problem-free reference solution to incorporate actual developments, we begin by estimating the impact of world depression on the Soviet economy. Given the extremely low ratio of foreign trade to GNP in the USSR, it is not surprising to find that the impact was very modest. The Soviet economy before 1929 had been relatively isolated from the world economy. After a brief burst of high-technology imports in 1929-32, Soviet authorities spurned further technological transfer. If pre-depression terms of trade had continued to be available, no doubt Soviet exports and imports would not have fallen off so severely (though it would have been very difficult to maintain grain exports after 1932). History shows, nevertheless, that industrial expansion was not curtailed by the cutbacks in Soviet imports.

Next we estimated the impact of Soviet rearmament. Toward the end of the decade direct outlays on national defense became a heavy burden, cutting sharply into household consumption and civilian fixed capital formation. However, if one counts military hardware as capital, total capital stocks are larger under rearmament than in the reference solution. The results of a solution combining the effects of world trade depression and rearmament are about the same.

The impact of these two exogenous developments, forced on the USSR from the outside, was far outweighed by the effects of collectivization. After further adjusting KAPROST to reflect the actual levels of fixed capital and output in both the field crops and livestock sectors, we find that household consumption over the years 1929-1940 is 37% lower than in

the reference solution. In the worst years it is almost 50% below what it might have been.

KAPROST also reveals that massive hidden underemployment must have existed in the Soviet Union in the 1930's. In the model, the same labor productivities are used in all simulation experiments. Under the problem-free solution, some of the available labor is not needed in the early years, when sharp structural shifts are underway. Rearmament delays full employment until the mid-1930's. But when the effects of forced agricultural collectivization are added, unused labor rises from 14% to an average of nearly 30% for the decade. Successive constrictions on the economy make more and more labor superfluous.

In fact, unemployment was not permitted. Soviet authorities kept everyone at work: on factory payrolls, on collective farms, in the Gulag archipelago. Average labor productivity in physical terms must have fallen far enough to absorb the whole labor force (except for the "excess deaths" which are not included in any of the solutions). Thus massive unemployment was camouflaged in the USSR, in constrast to the explicitly exposed unemployment in the West during the same period.

The Soviet drive for economic expansion was also adversely affected by grim changes in the domestic political environment that are not easily incorporated in a quantitative model. The purges and mass terror that peaked in 1937-39 reflected, in part, external threats; but the domestic tensions induced by forced collectivization of agriculture also seem to have been a major cause. The purges wreaked havoc in the armed forces, heavy industry and the railroads as morale was impaired and performance deteriorated. These destructive influences contributed to the pervasive way in which collectivization undermined Soviet growth.

The lesson for other countries is clear. Economic development involves basic changes in agriculture, but Soviet experience shows how large the cost of excessive haste can be. Our modeling procedures could be used not only to examine more recent Soviet developments or to decompose the past experience of other countries, but also to examine the current policy choices facing governments. KAPROST is a flexible instrument for modeling technological progress and structural change, combining a number of analytic devices already familiar to economic development specialists. Even those who have no interest in Soviet economic history will thus find our report and its appendices to be useful.

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Chapter I. INTRODUCTION AND SUMMARY

This study uses new tools in order to dissect Soviet economic experience during the crucial period from 1928 through 1940 when the foundations of the present economy were laid. These years saw a massive effort to restructure the whole economy by means of centralized controls focused on increasing certain kinds of output at maximum speed. Very substantial output increases were indeed achieved, and the control mechanism that came into being remains at the core of the Soviet economy even today.

The purpose here is to obtain a fuller understanding of the steps by which the Soviet economy was brought from its base-period situation in 1928 to the state that had been reached by the beginning of 1941. Output levels were raised, some manyfold and others scarcely at all. Input flows were enlarged and redirected. Sectoral proportions shifted markedly. The transformation occurred very rapidly, under conditions involving great tension and sacrifice. These were pioneering efforts in rapid economic development before the concept and goal of systematic economy-wide economic development had spread across the world. The prewar Soviet record thus has great significance, not only in its own right, but also for the lessons -- both positive and negative-- that it may have for other countries with similar objectives.

The main features of the record are already well established. Substantial studies, mainly by Western scholars, are already available. The most fundamental are a set of meticulous analyses reconstructing national income and product accounts for 1928, 1940, and the intervening year of 1937. These benchmarks make it possible to compute growth rates over the intervening periods, using alternative price weights. There are also detailed studies of individual sectors of the economy, tracing their evolution in detail. Several economic histories review the broad course of events and several insightful

analyses evaluate institutional changes. Major studies have investigated planning theory and planning practice. As a result of all this research, a fair measure of scholarly consensus exists concerning the broad outlines of what happened.

Building on this material, it now appears possible to deepen our understanding of the record by dissecting it and integrating it through applying an intersectoral, intertemporal model. That is what is done by the KAPROST (capital growth) model. KAPROST disaggregates the Soviet economy into ten producing sectors and subdivides the period after 1928 into six two-year periods. The model makes it possible to trace the direct and indirect requirements laid on each producing sector in each period by the major forms of final demand. KAPROST provides reconstructions for each period, not only of final demand and value added, but also of intersectoral flows. The six periods are linked together by the process of capital formation, which can be followed in detail. One can also trace the pattern of structural change in output and input use, period by period. The model imposes order on relations among all the economy's parts in each period, while simultaneously enforcing consistency as the economy moves from one period to the next.

This modeling effort allows the investigator to compare actual developments with the economy's potential. Having assembled a consistent summary of actual developments, we can see if the potential that lay in the Soviet economy at the end of the 1920s was in fact realized thereafter. Through enlarging the labor force and reassigning it, through building new capital plant and equipment embodying advanced technology, and through altering the structure of output, Soviet authorities were determined to uncover the potential lying unrealized in the USSR. We attempt to measure this potential and compute a problem-free reference solution for comparison with actual historical developments.

Differences between the expansion path traced out by the reference solution and the sequence of developments that actually occurred reflect the impact of several major events; our approach permits us to offer crude estimates of the separate impact of each event. In effect, the actual record is decomposed so that causal influences are measured.

Initial skepticism concerning the feasibility of estimating the Soviet economy's potential is certainly in order. One can have doubts about both the conceptual meaningfulness of a statistical framework capable of answering the question and also have doubts about the availability of reliable evidence from Soviet sources. Conceptual doubts can perhaps be removed through detailed presentation of the model itself; we set this forth in Chapter III. Doubts concerning the availability of reliable evidence are more easily dealt with. The key point is that for measuring the economy's potential in the late 1920s we can rely on ample, detailed Soviet data assembled before Stalinist pressures distorted the evidence. In fact, Soviet planning agencies had, by 1929, assembled data for most of the economy in volume and detail that would be the envy of most developing-nation planning agencies today. As explained briefly in Chapter II, the planners spent some eight or ten years building up a comprehensive data base reaching to all significant aspects of the economy. Reservations concerning definition and coverage within national aggregates can generally be removed through inspection of sectoral and regional detail. Though Soviet standards for statistical explanation fell short of the best Western practice, the availability of numerous alternative estimates permits an adequate resolution of most interpretive issues.

Parameters derived from this base-period evidence embody the properties of the 1928 economy, i.e., labor and capital productivities, input-output coefficients, worker and peasant consumption patterns, fixed capital gestation

periods, etc. The first Five-Year Plan, supplemented by related Gosplan and TsUNKhU material, provides data permitting derivation of the parameters that can be seen as governing the process by which the economy could expand from its 1928 starting point along the lines intended by the Party. The parameters governing expansion are derived incrementally in a way that unhooks them from the 1932/33 terminal year of the first Five-Year Plan, so that rates of feasible expansion subject to these constraints can differ from the rates laid down in the "optimal" version of the first FYP. (It was, in fact, discovery that the first FYP was infeasible that led to the formulation of the KAPROST model as an analytic device for uncovering the economy's feasible potential.) In order to carry the test forward as far as 1940, it is also necessary to supply exogenous estimates of the labor force, Soviet exports, and government purchases, together with assumptions regarding a few parameters, all of which can be varied in order to test their implications. With the addition of an objective function embodying the purposes of the system's directors, this whole set of relations forms a linear programming problem that can be easily solved on present-day computers. Variation of key parameters or variables alters the solution values that make up an answer. Through systematic experimentation one can feel out the contours of the economic system constraining the expansion process, discovering also which parameters and variables have the most decisive impact on the results.

The evidence available on actual Soviet developments comes partly from official Soviet sources but mainly from Western scholars who have reconstructed Soviet data in an effort to assure uniform coverage and stable price weights. From the early 1930s through the mid-1950s, official Soviet data were either withheld or issued in distorted or misleading forms. Over the last twenty years or so, retrospective information on the 1928-1940 period has improved, as official sources have released undistorted series, or as Soviet scholars have

made use of the underlying evidence available to them, but very little thorough reconstruction of primary official evidence has been reported. In spite of large remaining gaps, it has proved possible to assemble a record adequate to the needs of this project.

The KAPROST model has several distinctive features, designed to make it match up with the special character of the Soviet system. Like all linear programming models it is purposive rather than passive, in the sense that its activities are directed toward maximizing the value of an objective function. In development modeling the maximand is usually household consumption, which appears in the KAPROST objective function as well. Maximization of household consumption over several periods requires that current resources go into fixed capital formation in order to enlarge the capital stocks of sectors delivering final demand to households. But since gross output is delivered to other forms of final demand as well: public consumption, national defense, and non-defense government final use, some capital formation is motivated by non-consumer objectives. In the USSR the system's directors have seemed to attach independent value to growing stocks of fixed capital as symbols of strength. In Marxian terms, accumulation has at least equal weight with consumption as a goal of economic activity. The KAPROST objective function therefore includes terms for stocks of fixed capital in each of the ten sectors at the end of 1940, and the weights on consumption terms and capital stock terms can be varied to reflect alternative policy emphases.

The model includes both demand-side and supply-side constraints on output expansion, but the relationships involving effective demand and the disposition of income are secondary, while the real, physical limitations on activity levels and additions to capacity are the decisive constraints. In this respect KAPROST accurately matches the Soviet system of the 1930s, when

through forced saving and taxation the authorities overrode any private unwillingness to finance nonconsumption activities. In the same vein the model provides flexible levers for manipulating the flows of output going separately to workers and peasants so that the extent of belt-tightening can vary from period to period for each part of the population. It is thus possible to recreate the changes that occurred and compare them with hypothetical alternatives.

Perhaps the most distinctive features of the model relate to the way technological progress is brought into play. Each producing sector can draw on two stocks of fixed capital plant and equipment. One stock is the old capital on hand at the end of 1928, embodying prevailing technology. The other stock existed at that time only as small amounts of unfinished new capital, to be augmented thereafter through investment. This new capital embodies advanced technology, in the literal sense that it incorporates the best practice available from the West at the end of the 1920s. The old capital in each sector simply depreciates, while new capital comes into use -- after a specified gestation period -- in those sectors toward which investment is directed, at a speed determined by the optimizing procedure. As advanced-technology capital replaces old-technology capital in each sector, technological progress becomes visible, in a pattern and at a rate of speed reflecting the purposes of the regime interacting with the potentials in the situation. In addition to this flexible procedure for modeling the transition to use of improved technology, we add a parameter that reflects the fact that new capital does not produce at 100% of capacity until it has been "mastered."

This vintage approach to technological change is peculiarly appropriate for Soviet experience in the 1930s because after an initial burst of imports from Germany, the US, the UK, France, and a few other suppliers of machinery

and equipment, the USSR devoted the rest of the decade to "mastering technique", importing very little and making only modest changes in the technology embodied in their rapidly-growing stock of fixed capital.

In choosing an optimal degree of disaggregation for this project, we were conscious of the desirability of reflecting major policy emphases and alternatives while simultaneously holding down data requirements and preserving interpretability. Classical input-output models often involve several dozen sectors, but in a multi-period programming model this degree of disaggregation quickly becomes unmanageable. On the other hand there was no need to be confined to a two-sector model like that employed by Gisser and Jonas in their paper on "Soviet Growth in Absence of Centralized Planning". Our concern for capital formation suggested that a construction sector should play a distinct role, and our stress on changes in the structure of capital suggested that sectors with large stocks of fixed capital in 1928 should be recognized, perhaps even subdivided.

For these reasons we have rearranged the underlying evidence so as to form ten producing sectors. Agriculture is subdivided into field crops (together with forestry) and livestock products (together with fishing and hunting). Industry is subdivided into producer goods and consumer goods. Production of electric power, at the very center of Party priorities, is kept separate from producer-goods industry to form its own sector, and construction is a separate sector as well, playing a key role. Transportation and communications make up a large, capital-intensive sector, and housing (both urban and rural), though given low priority by the Party, makes up another distinct sector with a large stock of inherited capital. Finally, though considered non-productive in Marxian terms, a trade-and-distribution sector and a government services sector are recognized as significant users of labor

and capital. Though interindustry flows among branches of industry are not traceable in any detail under this approach, our sectoral scheme suffices to illuminate the key policy issues of the period.

To set the stage for a detailed reconstruction of the base period situation, we begin in Chapter II with a brief summary of Soviet economic goals, the resources available and two special factors that conditioned Soviet efforts. These features of the Soviet situation, in turn, have influenced the structure of the model we have designed to analyze the Soviet record.

First, as to goals, the fundamental economic aim was "to catch up with and surpass the advanced countries." This meant primarily a drive to build non-argicultural activities in order to achieve three sub-objectives. Modern industry would enable the regime to win its contest with the peasantry through supplying them with tractors, machinery, and the modern methods that would wean them away from their petty bourgois ways. Building a strong heavy industrial base would defend the country against hostile capitalist encirclement. In long run terms, a modernized economy would generate high labor productivity and living standards, thus demonstrating the superiority of the Soviet system.

In working toward these goals, the USSR could make use of an ample labor force and a rich base of land and natural resources. There was also an impressive stock of fixed capital already in existence, but, as shown below in Table III-1, Soviet fixed capital in 1928 was chiefly in agriculture, transportation, and residential housing. Industry accounted for only 9% of the total, suggesting that the drive to catch up with and surpass should be concentrated on building industrial capital.

In seeking to formulate and carry out economic development plans, the authorities could draw on almost a decade of data collection and planning

experience. Statistics with steadily expanding coverage provided base-period evidence that could be used for projecting changes. Both government departments and producing enterprises had gained some experience with efforts at operational planning.

Two special factors conditioned interaction between these goals and the wherewithal applied to them. One was the country's international political situation. Moscow saw itself surrounded by hostile capitalist powers unwilling to provide economic support except on the harshest commercial terms. The Soviet authorities sought economic independence, even if it had to be achieved through initial dependence on technology transfer from the West. Thus by comparison with the practice of most developing nations today, Soviet plans have from the beginning given only a small role to foreign trade.

A second conditioning factor was the Party's attitude toward prices and markets. Since prices and markets were seen as the operational essence of capitalism, Party members from top to bottom were suspicious of them. The Party was predisposed instead toward using administrative, non-market instruments for guiding economic activity. On ideological grounds, physical allocation of supplies, together with administrative allocation of budget funds, were strongly preferred over responses to market demands.

Our model therefore provides much less detail on the economy's external relations than is usually found in economic development models, though the specification does permit some crude testing of the impact of world depression on the Soviet economy. The model also stresses relationships that, conceptually at least, run in real terms. Here, too, the emphasis is rather different from that of the usual development model. In linear programming and input-output economics, the real side and the value side are inextricably bound toghther, but in moving the levers that determine model outcomes, we will be evaluating

Soviet experience in manipulating the "real" levers.

In chapters III and IV we present the statistical evidence underlying our effort to measure the economy's potential at the end of the 1920s and explain how the KAPROST model was calibrated to match the data. We ask: how rapidly could output be expanded, in the directions intended by the Party, under problem-free conditions? Marked structural change in the composition of output and inputs was sought, subject to the constraints imposed by the existing situation and the time required to bring about changes. We extract specific measures of the constraints through incremental dissection of the data prepared by Gosplan and TsUNKhU for the first Five-Year Plan, unhooking the parameters from the year 1932-33, when the first FYP was supposed to end, and making them part of a flexible analytic framework.

On the basis of this evidence, KAPROST computes a problem-free solution showing in ten-sector detail how the Soviet economy might have expanded from 1928 through 1940 if planners' expectations had prevailed. In early 1929 they did not anticipate the collectivization of agriculture that swept across the country in the fall and winter of 1929-30. Nor did they anticipate the world depression that turned the terms of trade sharply against Soviet commodity exports and imports. Finally, they made no provision for channeling current output into defense procurement. We therefore obtain a reference solution embodying the optimistic hopes of the system's directors in the absence of these three negative developments, each of which made expansion more difficult. In several respects the reference solution is perhaps unduly optimistic, though it bears no resemblence to the widly unrealistic targets that were bandied about in the early 1930s. It illustrates the upper range of outcomes reflecting the economy's potential.

The central message of our reference solution is that the Soviet economy in the 1928-1940 period contained a very substantial potential for output expansion, under problem-free conditions, without much need for belt-tightening. In view of the situation that prevailed in the base period, no elaborate model is needed to suggest such a conclusion, since the resources and growth possibilities were obviously at hand. The model provides systematic and consistent estimates, however, of the gains that might have been achieved. The Soviet gross national product, for example, might have risen more than four-fold, and the stock of fixed capital at the beginning of 1941 might have been five times larger that it was at the beginning of 1929. Consumption would have increased some 2.7 fold while investment was rising from an index of 100 to an index of 824.

Chapter V presents the best available current evidence on actual economic developments, in continuous annual time series, over the 1928-1940 period, for our ten sectors. The evidence is compiled mainly from Western sources, free of the distortions that afflicted official Soviet figures. An appreciable margin of error remains, no doubt, but the series appear to provide a workable basis for appraising the course of events. These statistics of course reflect the impact of agricultural collectivization, world depression, rearmament, and all the other difficulties that struck the Societ economy. Can they be built into KAPROST?

In chapter VI we show that they can. We begin by altering the export and import parameters of the reference solution to incorporate the impact of world depression on the domestic Soviet economy. It proves to be slight. We then introduce Soviet rearmament into the model, taking account both of defense procurement and of other claims by the armed forces on the economy. The defense

impact is appreciable, especially toward the end of the decade. We also test the combined influence of world depression and rearmament, seeking to show the joint influence of these two external forces on the Soviet system. By comparison with the problem-free reference solution, we find that though total gross output is not much affected, household consumption is reduced about 22% in the mid-Thirties and about 43% at the end of the decade.

The greatest damage is caused, however, by agricultural collectivization. Adjusting KAPROST to reflect collectivization lowers gross output substantially throughout the whole period, while imposing a drastic cut in household consumption, which is 32% lower in the mid-Thirties and 55% lower over the last four years. The loss of draft animals and productive livestock due to collectivization did far more than reduce the flow of livestock products to light industry and to the population. It forced industry to deliver tractors and other agricultural machinery to field-crops agriculture more promptly than had been intended, thus making non-agricultural capital formation more difficult. It also lowered labor productivity, both directly in agriculture and indirectly throughout the economy, Probably the most important consequence of collectivization, though it is not directly measurable by KAPROST, was the political tension and pressure that this "second revolution" spread throughout Soviet society, culminating in political purges and mass terror. This is the tragic human story that lies behind the laconic figures in our computations.

Rearmament and collectivization, especially collectivization, also prevent the economy from making effective use of the whole labor force. In our problem-free reference solution, after structural shifts have been accomplished, KAPROST employs all workers and peasants from 1933 through 1940. In our composite reconstruction, reflecting the impact of collectivization and rearmament, somewhere between a fifth and a third of the labor force is super-

fluous, at least given the labor productivity that prevailed in 1928 and was expected for the 1930s. The unemployment shown by KAPROST was in actuality camouflaged by government policy. The Constitution of 1935 declared that unemployment did not exist in the USSR, and in fact everyone was kept at work, on payrolls or in kolkhozy or in corrective labor camps. Average labor productivity per person in physical terms fell far enough below its potential to absorb the superfluous labor. Massive unemployment was thus concealed, by contrast with the explicitly exposed unemployment in the West during the same period.

To summarize this exercise in ex post planning, we suggest that its findings be taken with a grain of salt. The statistical evidence is fragile and the model is rather crude. With better data and a more sophisticated model, the results could be made more precise. It is not likely, however, that their implications would be significantly altered. This period in Soviet experience was a harsh one. Great sacrifices were made, whether necessary or not, and much was accomplished, however wastefully. Let us hope that other countries will be able to carry out these tasks at lower costs.

Chapter IV. Calibrating the Model to Obtain a Problem-free solution

In this chapter we report on computations intended to uncover the potentials that lay in the Soviet economy at the end of the 1920s, had it expanded along the lines intended by the Party and spelled out in the first FYP. We employ the data derived from the first plan and several related Gosplan documents as described in the preceding chaprer. These base-period levels and associated parameters are fitted to the KAPROST model, which then computes a complete set of values for output, employment, capital stocks, etc., over the next six two-year periods through the end of 1940. After a series of adjustments we obtain a problem-free solution which can then be compared with actual historical developments in an effort to trace the impact of major events on the economy.

The process of establishing a good reference solution itself requires a series of adjustments. We found it necessary to restate the specification of both our household consumption equations and our formulation of the post-terminal constraints on capital formation and to modify somewhat our base-period fixed capital estimates. After describing these calibration adjustments, we present a reference solution, one designed to reflect a balanced emphasis on both capital accumulation and household consumption. This baseline solution is not meant to be optimal in a welfare sense, since we lack the evidence required to form such a judgment. The baseline solution illustrates, however, the general dimensions of the expansion that might have unfolded over the 1928-1940 period in the absence of any complications.

Evolution of the Consumption Equations

The treatment of consumption and its structure in KAPROST is fairly straightforward. However, experience forced us to modify an initially rigid structure in order to obtain economically reasonable solutions. In this section we describe the motivation for and precise forms of those changes.

Table IV-1 reproduces the model's consumption-related equations. Income of both peasants and workers is determined by wage payments to those who are employed (equations 1.1 and 1.2). We relate total consumption to income by means of an "average propensity to consume" parameter-- α for peasants, β for workers--in equations 2.1 and 2.2. These parameters may also be viewed in another way. Any KAPROST solution which emphasizes investment over consumption will cause the constraints in equations 2.1 and 2.2 to be binding, that is equalities. As we do not provide for private savings, $(1-\alpha)$ and $(1-\beta)$ may be considered inflation or taxation rates: the factors by which the government reduces the real value of wages paid. It is entirely consistent with the Soviet record for the model to provide a parameter by which consumption may be lowered in order to divert output to other uses.

Total consumption must be broken down into demands for the output of specific producing sectors of the economy. Equation 3 was our initial specification. The parameters π and ω were vectors representing how one ruble of peasant and worker consumption (respectively) was allocated among the outputs of the producing sectors. The shares were derived from actual 1928 and planned 1933 consumption figures (as described in Appendix C).

When the model was solved using equation 3 (with α and β set at .7, close to historically observed values) we obtained solutions which left large amounts of unused capital and unused labor in all periods. This is totally at variance with the full employment, full resource utilization policy of the

Soviet Union. The computed outcome reflected a lack of capacity in two sectors: housing and trade-and-distribution, both of which produce output primarily for consumers. As worker and peasant income rose, the fixed pattern of consumption placed rising demands on these sectors, and when capacity was exhausted, no further employment was possible. This bottleneck could be alleviated by lowering α and β to .5 or at times .3, thereby spreading the output of the consumer - critical sectors more thinly. However, there was no means for the model to increase worker and peasant consumption in other sectors to compensate.

The Soviet (and most developing country) experience is that housing, trade and distribution, civilian transport and communication—in sum the entire consumer infrastructure—are allowed to be overcrowded and overutilized, even to deteriorate, in the initial stages of growth. Consumers are at least partially compensated by increased availability of food and manufactured items. Hence the image of the Soviet worker who waits in lines to buy everything, and then takes it back to his--by our standards--overcrowded apartment.

In modifying KAPROST, therefore, we needed a way to limit the portion of consumption which was required to be satisfied in strict proportions. In some sense these proportions represent consumer preference, as Soviet markets in 1928 were relatively free. (A second reason to retain their influence in the model was to insure that peasants and workers received a minimal selection from all sectors producing consumable goods.) But we also wanted to introduce the capability for the solution to provide the unrestricted portion of total consumption from any sector with slack capacity. Clearly this would have to be examined for reasonableness in each solution; it would not make sense, for example, to provide lopsided amounts of producers goods for consumption. These two provisions, limiting the sector-restricted portion of consumption, and

providing compensating consumables from other sectors, along with our ability to control the real value of income in terms of total consumption, would give us the flexibility appropriate to the situation we were modeling.

Equations 4.1 and 4.2 were finally used in KAPROST, reflecting these desiderata. In 4.1, the consumption demand on any producing sector consists of portion, ρ, of total peasant consumption CP multiplied by the consumption structure vector π; a similar contribution for workers with ξ, CW and ω, respectively; and an amount of optional consumption, OC. Equation 4.2 restricts the sum of the fixed-proportion components of consumption (ρ, CP and ξ CW) plus all optional consumption, to equal the total of worker and peasant consumption. With this structure we could obtain model solutions which combined full-employment with reasonable levels of consumption. By paying attention to capacity, and adjusting the α, β, ρ and ξ parameters, we are able to provide the contribution to optional consumption realistically from sectors such as agriculture, consumer goods, etc. The reader will note that the model cannot allocate optional consumption to workers and peasants directly, as two sets of OC variables would not be independent.

Table IV-1

Evolution of the Consumption Sector

(1.1) $YP_t = \sum_{i=1}^{2} w_{i,t} \; (L^o_{i,t} + L^n_{i,t}) \quad t = 1, \ldots, T$

(1.2) $YW_t = \sum_{i=3}^{10} w_{i,t} \; (L^o_{i,t} + L^n_{i,t}) \quad t = 1, \ldots, T$

(2.1) $CP_t \geq \alpha \; YP_t \quad t = 1, \ldots, T$

(2.2) $CW_t \geq \beta \; YW_t \quad t = 1, \ldots, T$

(3) $F_{i,t} = \pi_i \; CP_t + \omega_i \cdot CW_t$

$i = 1, \ldots, 10; \; t=1, \ldots, T.$

(4.1) $F_{i,t} = \pi_i \, \rho_t \, CP_t + \omega_i \, \xi_t \, cw_t + OC_{i,t}$

$i=1, \ldots, 10; \; t=1, \ldots, T.$

(4.2) $\rho_t \, CP_t + \xi_t \, CW_t + \sum_{i=1}^{10} OC_{i,t} = CP_t + CW_t$

$t = 1, \ldots, T.$

YP = peasant income
YW = worker income
w = wage
L^o = labor employed, old technology industry
L^n = labor employed, new technology industry
CP = total peasant consumption
CW = total worker consumption
F = consumption demand to a particular sector
OC = optional consumption

Treatment of Sectoral Proportions Among Terminal-period Capital Stocks

As pointed out earlier, the Party intended marked structural change in the sectoral proportions of Soviet fixed capital stocks, change that would even be evident by the end of the first plan period. Longer-term analyses foresaw further structural change, but without specifying any detailed sectoral estimates. Some mid-point evidence is provided by targets for 1937 in the second FYP as confirmed in January 1934. In Table IV-2 we show the percentage shares of each of our ten sectors in total fixed capital stocks in 1928, as intended for 1938, and as projected to the beginning of 1941, assuming constant absolute growth and assuming constant percentage growth at 1928-1933 rates. The patterns differ quite markedly and no clear inferences can be drawn from them. The 1933 and 1941 distributions reflect underlying absolute estimates in 1928 prices, while the distribution for 1 January 1938 reflects computations in the second FYP, using so-called 1933 prices whose underlying basis is not well understood. In projecting forward the 1928-1933 trends, we have deducted depreciated old-technology capital from the terminal figure in order to focus on investment intentions. One notes that small but rapidly growing sectors, like electric power and construction, increase their shares markedly under a constant percentage growth assumption, while sectors with large initial shares, like housing and transportation, retain large shares under projection using constant absolute increments.

It would be technically feasible to impose any one of these patterns on the model, requiring it to bring into being terminal-year fixed capital stocks in precisely these proportions. Apart from the uncertainty of choosing among these alternative muddy clues to Party intentions, a further consideration militates against imposing rigid constraints here. The Party attached high priority to electric power and producer-goods industry, and much lower priority to housing and agriculture. But surely as the economy grew in these directions,

emerging opportunities would have been seized upon so that outcomes within a reasonably wide range of variation would have been acceptable. Our modeling procedures permit us to juggle weights to simulate a variety of computed outcomes, choosing those with the most attractive composite results. This is far preferable to imposing rigid proportions that would force the optimizing procedure to meet specifications requiring needless sacrifices of output.

Table IV-2. Structure of Fixed Capital Stocks, By Sector, Actual 1928, Intended 1938, and Intended 1941, in percent shares of the national total.

	1928	1938	1941(a)	1941(b)
Agri., field crops	13.2	8.0	6.7	11.9
Agri., livestock products	11.3	3.6	4.3	8.1
Electric power	1.0	4.8	16.4	5.5
Industry-producer goods	4.7	25.0	23.2	15.0
Industry-consumer goods	4.3	8.7	5.3	6.5
Transport & communications	18.1	20.7	11.4	17.0
Construction	1.0	2.0	5.6	3.4
Housing	36.6	13.7	9.5	18.4
Trade & distribution	0.8	1.2	9.9	3.9
Government services	9.0	12.3	7.7	10.3

(a) Assuming constant percentage growth at 1928-1933 rates.
(b) Assuming that the intended 1928-1933 absolute annual increments continued.

Source: 1928 and 1941 estimates derived from computations for active fixed stocks at the beginning of the year. Depreciated old capital is deducted from the projected 1941 stocks. The 1938 estimates are based on absolute data in an English-language edition of the second FYP, p. 265. Agricultural capital subdivided in proportion to gross output; electric power capital derived from investment data and deducted from Group A industry; construction capital set equal to the figure for "miscellaneous" in the Gosplan table.

Evolution of the Post-Terminal Constraint

Economists who have used dynamic optimizing models recognize the importance of properly specifying terminal conditions. Unconstrained, the "optimizing devil" will "eat, drink and make merry" in the end, making no provision for a tomorrow which it does not know exists. In a growth model such as ours, this behavior takes the form of a failure to invest during the terminal, and perhaps earlier, periods.

The task of the terminal constraint in KAPROST is, therefore, to maintain investment at economically reasonable levels even when the resulting capital stock will not improve the value of the objective function. If these reasonable levels could be pre-specified, the form of the constraint would be very simple. At a minimum, this suggests that it would be plausible to provide for enough investment in new capacity to continue at the rate already achieved. Hence the stringency of the terminal constraint will depend on the optimal solution values, and its form must be built around them.

Table IV-3 lists the various forms of post-terminal constraints experimented with at various times in KAPROST. The last equation is the one currently in use. The naming conventions used are described fully in appendix B; the footnote to the table is only intended as a reminder. Note that common to each form is a post-terminal growth parameter, γ, which allows us to tighten the constraints parametrically. Further, all are in terms of the increment to capital stock in the second post-terminal period. As the investment structure in KAPROST requires two periods for building capital, this increment draws on fixed investment in the terminal period. (The increment in period T+1 contributes to the objective function, so need not be maintained by constraint.)

Equation 1, the initial version of the constraint, requires that investment be maintained at a level to cover total depreciation (plus whatever "extra" is required by the γ parameter). This was felt to be unsatisfactorily low. Given

Table IV-3

KAPROST Post-Terminal Constraints

(1) $z^N_{i,T+2} \geq (1+\gamma) d^N_i K^N_{i,T+1} + d^O_i K^O_{i,T+1}$

$i = 1, \ldots, 10.$

(2) $z^N_{i,T+2} \geq d^N_i K^N_{i,T+1} + (1+\gamma) [K^N_{i,T+1} - K^N_{i,T}]$

$i = 1, \ldots, 10$

(3) $z^N_{i,T+2} \geq \frac{1}{6} \sum_{t=2}^{T+1} K^N_{i,t} + \gamma_i K^N_{i,T+1}$

$i = 1, \ldots, 10$

$z^N_{i,t}$ = increment in new technology capital stock, for sector i, period t

$K^N_{i,t}$ = new technology capital stock, sector i. period t

$K^O_{i,t}$ = as above, for old technology.

d^N_i = depreciation rate, new technology capital, sector i.

d^O_i = depreciation rate, old technology capital

γ_i = post-terminal growth parameter.

a high growth solution, with most of the increment to capital stock in the final period, the increment provided for capital in period T+2 would be significantly less than the increment in the previous period. While increasing γ could obviate this somewhat, one can't know how high to set γ unless one knows the solution values. However, altering γ changes the solution, and so on. It is worth emphasizing that a parameter like γ is meant to allow the model user to tighter the constraint, and not to correct flaws in specification.

The second equation calls for the T+2 capital increment to cover the depreciation of new capital, and to provide for the same increase from period T+1 to T+2 as the solution calls for from period T to T+1. This is a "same growth" requirement (with $\gamma > 0$ indicating somewhat more than same growth), seemingly very reasonable. However, the optimizer interpreted this quite differently from the way we intended. Our solutions showed this constraint raised the cost of increments to capital stock in period T+1 so much that it was optimal to build a very large stock by period T, and then allow it to depreciate. Hence rather than maintaining investment in the last period, we had inadvertently eliminated it in the last two periods!

Equation 3 gives our final version of the terminal constraint. The capital increment in period T+2 must equal the average increment in the preceding six periods, plus some fraction γ of capital stock in T+1. The γ parameter is set equal, initially, to the level of depreciation in each sector. Hence the constraint requires the model to cover depreciation and to maintain the average per-period increment in fixed capital. In practice this specification has worked well. However, one might suggest a different pattern for the weights on previous capital increments, instead of a simple average. We considered this, until we realized that any altered set of weights would force investment artificially away from the periods with the large weights as these periods would be contributing more heavily to the post-terminal burden. As we had succeeded in

maintaining investment expenditure, we felt that the work involved in a more sophisticated weighting scheme was not justified.

Adjustment of Initial Capital Stock and Capital Productivity

In KAPROST two periods or four years are required to add to capital stock. This implies that maximum output and capital stock levels for the first two periods are fixed by the choice of exogenous values for initial capital stock, initial increments to capital stock, and output-capital ratios. Our initial experience with values calculated from Soviet data (see Appendix C) revealed two problems: in most sectors capital stock and productivity ratios would not allow the model to produce output at historic levels; initial capital stock and increments would not permit the model to attain historic capital stock levels in the second period. This indicated shortcomings in the data, especially the estimate of initial increments to capital, the projects in progress in 1928 before the start of the simulation.

Altering the output-capital ratios for the first two periods to allow the model to achieve historic production levels is not a major problem. These coefficients tend to fluctuate in any economy, and we know that in the early 1930's various productivity campaigns caused a sharp rise in output above expectations. For the remaining four periods the output-capital ratios can be reduced back to anticipated long-run values.

Altering initial capital stock levels, however, is, in essence, giving the model extra resources at no cost. Higher levels of output are paid for by direct demands on production through the input-output matrix, and indirect demands on production through employment and consumption. Higher initial capital stocks provide free increments in capacity throughout the model's simulation horizon, diminished only gradually by depreciation. Clearly this is not acceptable.

We resolved the capital stock problem by increasing the initial increments

to capital stock (variable $\overline{a}_2^N$), the initial investment pipeline, and by changing the constraint in which it appears from an equality to an inequality. This is appropriate for three reasons. First, the increments, if large enough, will allow the model to achieve historically observed capital stocks for the second simulation period, 1931-1932. Second, by increasing the initial increment, rather than the initial stock, of capital, the added capacity can be obtained only at a price. In terms of the investment dynamics in KAPROST, the initial increment is in its second investment period (third and fourth year of construction) in the first simulation period (years 1929-1930). As three-fourths of the cost of investment is incurred in the second investment period, the model solution must use three rubles of current output for every four rubles of capital it chooses to build. Taken together with the fragile underlying evidence on the volume of development projects in progress when the model solution starts, this formulation appears quite plausible. Third, by requiring the model to add at most the exogenously specified increment, rather than exactly the increment, we allow some of these pre-plan projects to be left forever unfinished. This allows the solution more of a choice in terms of investment versus consumption in the first period. In actual practice, the optimizing procedure always chose to invest in the increment, and would have built even more capital if allowed.

Our precise adjustments are indicated in Tables IV-4 to IV-7. Table IV-4 shows indices of fixed capital stock by sector on Jan. 1 of the years 1928, 1929 and 1931, with 1928 as a base year. In Table IV-5 we calculate the value of the initial increment in capital stock needed to permit us to match the historic levels implied by the indices in Table IV-4. To do this we calculate the initial stocks of old and new technology capital, and subtract the sum from the historic stock. In any sector where the required increment exceeds

Table IV-4. Actual Fixed Capital Stock, January 1, in millions of rubles

	1928		1929		1931	
Sector	Stock	Index	Stock	Index	Stock	Index
AF	8 224	100.0	8 553	104.00	9 889	120.25
AL	7 594	100.0	7 898	104.00	9 132	120.25
EP	600	100.0	676	112.67	1 114	185.72
PG	3 017	100.0	3 399	112.67	5 603	185.72
CG	2 618	100.0	2 570	98.17	2 508	95.79
TC	11 366	100.0	11 583	101.91	12 886	113.37
CO	595	100.0	670	112.67	1 105	185.72
HO	22 982	100.0	23 478	102.16	24 258	105.55
TD	487	100.0	508	104.23	570	117.12
GS	5 680	100.0	5 920	104.23	6 652	117.12

Source: Compiled from primary Soviet sources and adjusted as explained in Appendix A, pp. 23-27. Some of the figures here differ slightly from those in Table 7 of Appendix A, which reflect recent revisions and adjustments. Though recomputation of the reference solution has not yet been carried through, it is not likely to alter results appreciably.

Table IV-5. Adjusted Initial Increment to Capital Stock, $\bar{Z}_2^N$

Sector	(1) K_1^0	(2) K_2^0	(3) K_1^N	(4) Depr. K_1^N	(5) (2)+(4)	(6) K_{1931}	(7) Adjusted Z_2^N	(8) Original Z_2^N	(9) Reference Solution Z_2^N
AF	7 509	6 259	979	837	7 096	9 889	2 793	315	2 793
AL	7 011	5 975	954	814	6 789	9 132	2 343	40	2 343
EP	569	511	248	223	734	1 114	380	94	380
PG	2 861	2 573	524	478	3 051	5 603	2 552	08	2 552
CG	2 485	2 238	452	411	2 649	2 508	- 141	697	697
TC	10 959	10 188	649	603	10 791	12 886	2 095	331	2 095
CO	536	435	131	109	544	1 105	561	159	561
HO	22 086	20 397	1 404	1 305	21 702	24 258	2 556	479	2 556
TD	463	419	164	148	567	570	3	74	74
GS	5 519	5 210	246	233	5 443	6 652	1 209	213	1 209

(1) Initial Stock of old technology capital, Appendix C, Table 6.
(2) Column 1, depreciated by sector.
(3) Initial stock of new technology capital, Appendix C. Table 6.
(4) Column 3, depreciated by sector.
(5) = (2) + (4).
(6) Historic 1931 capital stock, Table IV-4 above.
(7) = (6) - (5), adjusted increments to capital in period 2.
(8) Initial increments to capital in period 2 as originally calculated, Appendix C. Table 5.
(9) = max ((7), (8)), increment to capital in period 2 used in reference solution.

Table IV-6. Adjusting Old Technology Output-Capital Ratios for First Two Periods.

Sector	(1) b_1^N	(2) K_1^N	(3) X_1^N	(4) X_1	(5) X_1^0	(6) K_1^0	(7) Adjusted b_1^0	(8) Original b_1^0	(9) Reference b_1^0, b_2^0
AF	3.15996	979	3 094	22 752	19 658	7 509	2.61793	2.67558	2.67558
AL	2.15026	954	2 051	10 320	8 269	7 011	1.17944	1.62549	1.62549
EP	1.35126	248	335	1 649	1 314	569	2.30931	1.88666	2.30931
PG	4.26434	524	2 235	42 032	39 797	2 861	13.91017	9.72754	13.91017
CG	5.53981	452	2 504	15 189	12 685	2 485	5.10463	5.46371	5.46371
TC	0.35464	649	230	5 878	5 648	10 959	0.51538	0.36284	0.51538
CO	13.07353	131	1 713	13 068	11 355	536	21.18470	13.06891	21.18470
HO	0.24250	1 404	340	3 606	3 266	22 086	0.14788	0.14742	0.14788
TD	3.87492	164	635	6 043	5 408	463	11.68035	11.60164	11.68035
GS*	0.90313	246	222	7 710	7 488	5 519	1.35677	1.04014	1.35677

(1) New technology output-capital ratio, Appendix C, Table 17.
(2) New technology capital in period 1, Appendix C, Table 6.
(3) = (1) x (2) = New technology output in period one.
(4) Historic output in period 1.
(5) = (4) - (3) = Old technology output in period 1.
(6) Old technology capital stock in period 1, Appendix C, Table 6.
(7) = (5) ÷ 6 = adjusted old technology output capital ratio in period 1.
(8) Originally calculated old technology output-capital ratio in period 1, Appendix C, Table 17.
(9) = max ((7), (8)) = Old technology output-capital ratio used in reference solution periods 1 and 2.

* Government Services output levels are the linearly interpolated values from Appendix C, Table 3.

Table IV-7. Adjusted New Technology Output-Capital for Second Period

Sector	(1) X^0_2	(2) X_2	(3) X^N_2	(4) Available K^N_2	(5) Adjusted b^N_2	(6) Original b^N_2	(7) Reference b^N_2
AF	16 750	23 599	6 849	2 792	2.45308	3.15996	3.15996
AL	9 710	7 567	<0	2 454	--	2.15	2.15026
EP	1 179	2 738	1 559	489	3.18814	1.35	3.18814
PG	35 787	53 632	17 845	2 264	7.88207	4.26	7.88207
CG	12 230	15 512	3 282	899	3.65072	5.53981	5.53981
TC	5 251	8 615	3 364	2 070	1.62512	0.35464	1.62512
CO	9 211	20 587	11 376	502	22.66135	13.07353	22.66135
HO	3 016	3 717	701	3 094	0.22657	0.24250	2.24250
TD	4 894	5 429	534	200	2.67000	3.87492	3.87492
GS*	6 196	9 279	3 083	1 079	2.85728	0.90313	2.85728

(1) Old technology output in period two, obtained by depreciating values in Table IV-6, Column 5 above.
(2) Historic output in period two.
(3) = (2) - (1) = New technology output in period 2.
(4) Available new technology capital stock in perios 2, obtained by depreciating values in Table IV-6, Column 2 above, and adding in 70 percent of Table ~~2~~ IV-5, Column 9 above (to allow for slow mastering of newly produced capital).
(5) = (3) ÷ (4) = Adjusted new technology output-capital ratios for period two.
(6) Originally calculated new technology output-capital ratios for period 2, Appendix C, Table 17.
(7) = max ((5), (6)) = new technology output-capital ratios for second period used in reference solutions.

* Government Services output levels are the linearly interpolated values from App[illegible]x C, Table 3.

Table IV-8. Output-Capital Ratios Used in Reference Solution.
(By Period and Sector)

Sector	Old Technology Period 1,2	Old Technology Period 3-6	New Technology Period 1,3-6	New Technology Period 2
AF	2.67558	2.67558	3.15996	3.15996
AL	1.62549	1.62549	2.15026	2.15026
EP	2.30931	1.88666	1.35126	3.18814
PG	13.91017	9.72754	4.26434	7.88207
CG	5.46371	5.46371	5.53981	5.53981
TC	0.51538	0.36284	0.35464	1.62512
CO	21.18470	13.06891	13.07353	22.66135
HO	0.14788	0.14742	0.24250	0.24250
TD	11.68035	11.60164	3.87492	3.87492
GS	1.35677	1.04014	0.90313	2.85728

Source: Tables IV-6, IV-7, and Appendix C, Table 17.

our earlier estimate for the initial increment, we insert the required increment in place of the origin^l estimate.

In Tables IV-6 and IV-7, we calculate the adjusted output-capital ratios, using the adjusted initial increment to capital stock. We increase the productivity of old technology capital to whatever level is required to achieve historic levels of output in the first solution period (1929-1930), after allowing for the contribution of new technology capital. This productivitv is assumed to continue in the second model solution period (1931-1932), and we increase the productivity of new technology capital stock in that period to cover any shortfall. Note that we take into account the mastering process which makes the additions to capital stock in any period only 70% effective

during its first two years. Note further that we never decrease output-capital ratios below the values calculated in Appendix C. Finally, Table IV-8 shows the output-capital ratios that are employed for the reference solution. Note that adjustments occur only in periods one and two.

Desired Characteristics of the Reference Solution

The logical first step in developing a reference solution is to take the adjusted equations and data, set reasonable values for the consumption and income parameters, set all objective-function weights at 1.0, relative to the final period (hence revising upward the weight on consumption in earlier periods by an appropriate power of the social discount factor), and then examine the result of the optimization algorithm. It should be obvious, however, that we still have a great deal of freedom in determining the characteristics of the solution in these last chosen parameters: average propensity to consume, fraction of consumption obtained in desired proportions, and objective function weights. Hence the first step, really, is to attempt to define what properties a reference solution ought to have, and then see if they can be achieved by varying these control parameters.

Note that we are not imposing a solution on the model; we are no longer changing any given economic data. Rather we are selecting one out of an infinite range of solutions inherent in the data. By varying, as Soviet planners might, the real value of income, the proportion of consumption satisfied according to consumer desires (as opposed to supply availability) and the relative importance of consumption in any period versus consumption in other periods and overall capital development, we can obtain quite different results. But our range of choice is limited by initial stocks, productivities

and the investment structure; these constraints cannot be circumvented.

Our reference, or baseline, solution ought to provide an idealized illustration of the Soviet economy's potential at the beginning of 1929. This would mean developing a solution which maintains total real consumption at 1928 levels, preferably increasing steadily from that base. Further, it would mean simultaneously building a capital stock by the end of our simulation horizon in no way inferior to that actually achieved in Soviet experience, and perhaps even superior to that standard. As should be clear from the structure of our model, these two goals, higher consumption and higher capital stock, must ultimately conflict. Hence developing the reference solution is a process of varying the accessible parameters with a fine sense of this balance in mind.

Developing the Reference Solution

We present a fairly detailed explaination of how the reference solution was developed because the process is typical of how all the solutions discussed below were developed. The cycle of solving the model, examining the results, and adjusting the parameters for another go, is tedious, but critical to the successful use of a model of this type. The user learns how the model reacts, and develops confidence through the reasonableness of those reactions (or goes back to respecifying the model if those reactions are inappropriate). Hence we describe the procedure once, leaving the reader to infer that the same procedure was used to develop solutions for the historical scenarios on Chapter 6 below.

The logical starting point in a search for a reference solution is to set the weights on all terms in the objective function equal to 1.0 in the

final period. This implies raising the weights on consumption in earlier periods by the appropriate power of the social discount rate, 10%, so that consumption in 1929-1930 has a weight of 2.59. Further, the average propensity to consume parameters were set at .5 for the first four periods, and .7 for the last two periods. Thus real wages were only permitted to be half nominal wages in the first period, etc. The fraction of consumption satisfied in fixed proportions was .1, .1, .7, .9, .95 and .95 for periods one through six respectively. Our previous experience with the model allowed us to recognize that the solution would permit higher real wages, with consumption more in line with peasant and worker preferences, in later rather than in earlier periods. Table IV-9 lists these control parameter values for this solution, #1, and for the other solutions leading up to and including the reference solution.

The overall performance of the solution is quite good (see Table IV-10). Over the 12 years, capital stock increase by a factor of 5, output by a factor of 3½, consumption by 2½. However, the detailed results are clearly unsatisfactory. There is a great deal of unemployed labor in the first four periods, rising to almost 20% in the fourth period. More importantly, new fixed capital is brought into production in sectors where the model finds it least costly to invest, rather than in those sectors to which the Party attached highest priority. Notice that the capital stock for the Government Services sector is nearly half the total. If one examines Appendix C Table 11 one sees that investment in this sector requires a smaller proportion of output from the Producer Goods sector than any other, and, as Producer Goods

Table IV-9. Parameter Values for Simulations Leading to the Reference Solution

	#1	#2	#3	#4	#5	#6	#7	#8	#9	Reference Solution
Objective Function Weights										
Capital Stocks, Jan. 1, 1941										
Agriculture, Field Crops	1.0	2.2	2.2	2.5	2.6	3.0	unchanged			
Agriculture, Livestock Products	1.0	2.3	2.3	2.5	2.6	3.0	unchanged			
Electric Power	1.0	3.0	3.5	3.3	3.2	3.2	3.2	3.2	3.2	3.0
Producer Goods Industry	1.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.1
Consumer Goods Industry	1.0	2.2	unchanged							
Transport and Communications	1.0	2.1	unchanged							
Construction	1.0	2.25	unchanged							
Housing	1.0	0.0	unchanged							
Trade and Distribution	1.0	0.0	unchanged							
Government Services	1.0	0.0	unchanged							
Consumption										
1929 and 1930	2.59	unchanged								
1931 and 1932	2.14	unchanged								
1933 and 1934	1.77	1.77	1.77	1.77	1.77	1.77	2.5	3.0	3.2	3.2
1935 and 1936	1.46	1.46	1.46	1.46	1.46	1.46	2.0	3.0	3.0	3.0
1937 and 1938	1.21	unchanged								
1939 and 1940	1.0	unchanged								
Consumption Parameters										
Average Propensity to Consume *										
1929 and 1930	0.5	unchanged								
1931 and 1932	0.5	unchanged								
1933 and 1934	0.5	unchanged								
1935 and 1936	0.5	unchanged								
1937 and 1938	0.7	unchanged								
1939 and 1940	0.7	unchanged								
Fraction in Fixed Proportions *										
1929 and 1930	0.1	unchanged								
1931 and 1932	0.1	unchanged								
1933 and 1934	0.7	0.7	0.5	unchanged						
1935 and 1936	0.9	0.9	0.5	unchanged						
1937 and 1938	0.95	unchanged								
1939 and 1940	0.95	unchanged								

* These parameters were set identically for workers and peasants.

Table IV-10. Solution #1 Millions of Rubles (Labor Force in Thousands)

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 739657.6

ELEMENTS OF THE OBJECTIVE FUNCTION

	SECTORS										
	AF	AL	EP	PG	CG	FC	CO	HO	TO	GS	TOTAL
CAPITAL-42	13261.5	10216.8	8350.3	27358.2	8235.9	25672.8	6634.6	25401.5	6014.	60178.4	292334.6

	YEAR							
	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
PEAS CONS	24514.9	20984.7	18552.8	13052.4	26017.6	30191.2		
WORK CONS	10567.3	13803.6	15752.2	21630.1	45196.1	53847.1		

OTHER SUMMARY DATA BY YEAR

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
OUTPUT								
OLD TECH	108766.4	100459.9	71140.1	54283.4	39852.3	5575.5		
NEW TECH	13359.3	48935.7	103210.8	192574.7	307066.6	397280.3		
TOTAL	122125.7	149375.6	174350.9	245858.1	346918.9	402855.8		
CAPITAL STOCK								
OLD TECH	59998.0	54206.1	49058.5	44473.4	40380.4	36719.0	33436.9	
NEW TECH	5751.0	20422.1	50417.0	77782.2	144165.9	208543.7	292334.6	
TOTAL	65749.0	74628.2	99475.4	122255.5	184546.2	245262.6	325771.4	
NEW CAPITAL		15260.0	32079.0	31881.7	73404.9	77676.3	101254.7	79410.4
LABOR FORCE								
SUPPLY	55350.0	58527.0	62859.0	65004.0	69480.0	73998.0		
EMPLOYED	51010.8	52651.0	54205.4	53120.0	69479.9	73997.8		
IDLE	4339.2	5876.0	8662.6	12884.0	0.1	0.2		
PER CENT	7.8	11.5	13.8	19.5	0.0	0.0		

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is the limiting sector for investment, Government Services capital is the "least expensive" capital that the model can produce. As the weighting of the objective function values each sector's capital stock equally, the optimizing algorithm's choice is algebraically impeccable.

In Solution #2 we chose to deal with the problem of the sectoral distribution of investment. This was done by making a subjective estimate reflecting the relative priority assigned to each sector by Soviet authorities in the 1930's. The ten sectors can be grouped quite easily: first priority went to the heavy industrial sectors, Producer Goods and Electric Power; second rank went to the two agricultural sectors, field crops and livestock, along with Consumer Goods (light industry), Transport and Communication, and Construction; while Housing, Trade and Distribution, and Government Services were put in a third category. We lowered the weights on the third group to zero, that is, removed them from the objective function entirely. This means that only enought capital stock will be built for these sectors to enable them to provide the output required by exogenous demands and the needs of more important sectors; in a sense these sectors will be dragged along by the momentum in the model solution. The weights for the first group were set to 3.0, making investment here more important than consumption. The weights for the second group were set just above 2.0, making investment in them more important than consumption in all but the first two periods (see Table IV-9).

The summary report for Solution #2 is given in Table IV-11. The same gross levels of investment, capital stock and output are achieved as in

Solution #1 (Table IV-10). However, the sectoral distribution of investment has shifted sharply away from Government Services to Producer Goods, whose capital stock now comprises nearly half the total at the beginning of the post-terminal period.

The shift has not been achieved without cost. The new intended pattern of investment is more out of line with the initial structure of the economy than that in the previous solution. This result is not unexpected, as a major structural shift was a conscious policy goal of all Soviet planners. In our model the process of structural change shows up most strongly in the solution values for periods three and four (1933-1936), as a review of the implementation of investment in the model will show. KAPROST requires two periods (four years) of investment to produce new capital stock. Therefore, as stressed earlier, capital additions in periods one and two had already been exogenously fixed. Only in the third period (based on investment plans chosen by the solution algorithm in the first period) are additions to capital stock responsive to the objective function weights. In theory it might take the third period alone, or the third period and any number thereafter, for structural change to be completed, that is, for capital stock proportions to be shifted into a pattern compatible with the long-run growth path implicit in the objective function weights and constrained by the input-output and investment relationships in the model. In practice, it would appear to require two periods, the third and the fourth. Solution #2 and all subsequent solutions in this chapter and in chapter six, show the highest unemployment and lowest consumption in periods three and four, with marked improvements in periods five and six. In particular, in Solution

Table IV-11. Solution #2 Millions of Rubles (Labor Force in Thousands)

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 1087744.0

ELEMENTS OF THE OBJECTIVE FUNCTION

	SECTORS										
	AF	AL	EP	PS	CG	TC	CD	HO	TD	GS	TOTAL
CAPITAL-42	15203.4	9990.1	10151.6	159259.8	8518.3	32864.5	4058.3	25485.6	5553.0	20832.1	292921.6

	YEAR							
	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
PEAS CONS	24974.7	21229.0	11086.3	11324.5	27513.9	30397.1		
WORK CONS	10554.5	13835.4	15411.9	21748.6	39173.5	51964.7		

OTHER SUMMARY DATA BY YEAR

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
OUTPUT								
OLD TECH	108660.2	100476.6	69326.4	48013.1	39332.4	5575.5		
NEW TECH	13359.3	48904.0	98962.6	199363.1	292757.7	400245.6		
TOTAL	122019.4	149380.5	168289.0	247376.2	332090.1	405821.1		
CAPITAL STOCK								
OLD TECH	59998.0	54206.1	49058.5	44473.4	40380.4	36719.0	33436.9	
NEW TECH	5751.0	20422.1	48478.0	81237.3	150589.6	210027.3	292921.6	
TOTAL	65749.0	74628.2	97536.5	125710.6	190969.9	246746.2	326358.4	
NEW CAPITAL		15260.0	30140.1	36988.9	76816.7	72548.4	101717.9	82818.1
LABOR FORCE								
SUPPLY	55350.0	59527.0	62859.0	65004.0	69480.0	73998.0		
EMPLOYED	50994.9	52652.7	47955.6	48332.6	69479.9	73997.8		
IDLE	4355.1	5974.3	14913.4	17671.4	0.1	0.2		
PER CENT	7.9	11.5	23.7	26.8	0.0	0.0		

Table IV-12. Solution #3 Millions of Rubles (Labor Force in Thousands)

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 1196707.0

ELEMENTS OF THE OBJECTIVE FUNCTION

	AF	AL	EP	PS	CG	TC	CD	HO	TD	GS	TOTAL
					SECTORS						
CAPITAL-42	14555.8	9948.2	139887.3	40277.4	8217.6	35953.7	2670.1	26153.1	5540.	0832.1	304045.0

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
					YEAR			
PEAS CONS	25062.0	21752.0	11073.4	11630.4	27327.7	30346.9		
WORK CONS	10544.6	13809.4	14999.5	25779.0	39723.0	51675.6		

OTHER SUMMARY DATA BY YEAR

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
OUTPUT								
OLD TECH	108584.8	100490.8	67603.5	64207.3	38615.9	4948.8		
NEW TECH	13359.3	48900.2	101236.8	195241.9	300637.4	405171.3		
TOTAL	121944.0	149390.9	168840.3	259449.2	339253.3	410120.1		
CAPITAL STOCK								
OLD TECH	59998.0	54206.1	49058.5	44473.4	40380.4	36719.0	33436.9	
NEW TECH	5751.0	20422.1	48110.2	79821.1	161500.3	222996.3	304045.0	
TOTAL	65749.0	74628.2	97168.6	124294.4	201880.6	259715.3	337481.9	
NEW CAPITAL		15250.0	29772.2	35939.1	88773.1	75655.0	101203.8	88422.8
LABOR FORCE								
SUPPLY	55350.0	59527.0	62859.0	66004.0	69480.0	73998.0		
EMPLOYED	50982.9	52656.4	47570.1	51463.4	69479.9	73997.9		
IDLE	4367.1	6870.6	15288.9	14540.6	0.1	0.1		
PER CENT	7.9	11.5	24.3	22.0	0.0	0.0		

#2, Table IV-11, unemployment in these periods rises above 20%, and peasant consumption falls sharply from Solution #1.

In order to improve consumption in the two middle periods, a more detailed examination of the second solution is required. We found that capital stock utilization in several sectors which contribute to consumption in fixed proportions, but not to investment - Housing in particular - was 100%. This bottleneck would not be removed by raising the objective function weights. Rather, it is best resolved by lowering the fraction of consumption which must be satisfied in fixed proportions. This "frees up" the limited housing stock, which may now be distributed among the larger number of workers which we expect the model to hire.

Solution #3, Table IV-12, shows the effect of lowering to 0.5 the fixed proportion component of consumption in periods three and four. In addition the weight on capital stock in the Electric Power sector was raised to 3.5 to see if investment could be switched away from the Producer Goods sector (all control parameter values are listed in Table IV-9). This second objective was clearly accomplished, as the largest sectoral capital stock is now Electric Power.

Examining the consumption and unemployment levels in solution #3 we see that our selection of control parameters was correct, even if not the best that could be hoped for. Unemployment is slightly higher in period three as compared to Solution #2 (24.3% vs 23.7%) but appreciably lower in period four (22.0% vs 26.8%). Workers consumption for 1933-34 and 1935-36 changes similarly - 15 billion rubles vs 15.4 billion rubles, and 24.8 billion rubles vs 21.7 billion rubles. However, the peasants are virtually

Table IV-13. Solution #4 Millions of Rubles (Labor Force in Thousands)

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 1176410.0

ELEMENTS OF THE OBJECTIVE FUNCTION

SECTORS

	AF	AL	EP	PG	CG	TC	CD	HD	TD	S	TOTAL
CAPITAL-42	14559.4	9947.0	112718.8	69748.9	8204.3	35892.0	2787.5	25974.0	5872.8	832.1	306546.6

YEAR

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
PEAS CONS	25018.8	21448.8	11110.5	13347.5	27150.9	30348.5		
WORK CONS	10548.0	13837.1	15019.3	24670.2	40514.6	51680.2		

OTHER SUMMARY DATA BY YEAR

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
OUTPUT								
OLD TECH	108611.2	100482.5	67674.1	64207.3	37299.3	4948.8		
NEW TECH	13359.1	43902.4	101861.0	198404.7	307348.8	405066.6		
TOTAL	121970.4	144384.9	169535.1	262612.0	344648.1	410015.4		
CAPITAL STOCK								
OLD TECH	59998.0	54206.1	49058.5	44473.4	40380.4	36719.0	33436.9	
NEW TECH	5751.0	20422.1	48292.3	80698.5	160823.7	225391.6	306546.6	
TOTAL	65749.0	74628.2	97350.7	125171.8	201204.0	262110.5	339983.4	
NEW CAPITAL		15260.0	29954.3	36646.6	87437.7	78652.1	101137.4	88535.8
LABOR FORCE								
SUPPLY	55350.0	59527.0	62859.0	65004.0	69480.0	73998.0		
EMPLOYED	50987.1	52654.3	47703.2	56189.7	69479.9	73997.8		
IDLE	4362.9	5872.7	15165.8	8814.3	0.1	0.2		
PER CENT	7.9	11.5	24.1	14.9	0.0	0.0		

Table IV-14. Solution #5 Millions of Rubles (Labor Force in Thousands)

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 1167590.0

ELEMENTS OF THE OBJECTIVE FUNCTION

	SECTORS										
	AF	AL	EP	PG	CG	TC	CD	HD	TD	GS	TOTAL
CAPITAL-42	14569.4	9947.0	112718.8	63748.9	8204.3	35892.0	2787.5	25974.0	5872.8	20832.1	306546.6

	YEAR							
	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
PEAS CONS	25018.8	21448.8	11110.5	13347.5	27150.9	30348.5		
WORK CONS	10548.0	13807.1	15019.3	24670.2	40514.6	51680.2		

OTHER SUMMARY DATA BY YEAR

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
OUTPUT								
OLD TECH	108611.2	100482.5	67674.1	64207.3	37299.3	4948.8		
NEW TECH	13359.3	48902.4	101861.9	198404.7	307348.8	405066.6		
TOTAL	121970.4	147384.9	169536.1	262612.0	344648.1	410015.4		
CAPITAL STOCK								
OLD TECH	59998.0	54206.1	49058.5	44473.4	40380.4	35719.0	33436.9	
NEW TECH	5751.0	20422.1	48292.3	80698.5	160823.7	225391.6	306546.6	
TOTAL	65749.0	74628.2	97350.7	125171.8	201204.0	262110.5	339983.4	
NEW CAPITAL		15260.0	29954.3	36646.6	87437.7	78662.1	101137.4	89535.8
LABOR FORCE								
SUPPLY	55350.0	59527.0	62869.0	66004.0	69480.0	73998.0		
EMPLOYED	50987.1	52654.3	47703.2	56189.7	69479.9	73997.8		
IDLE	6362.9	6872.7	15165.8	9814.3	0.1	0.2		
PER CENT	7.9	11.5	24.1	14.9	0.0	0.0		

Table IV-15. Solution 26 Millions of Rubles (Labor Force in Thousands)

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 1177377.0

ELEMENTS OF THE OBJECTIVE FUNCTION

	SECTORS										
	AF	[illegible]	FP	PG	CS	TC	CO	HO	TD	[illegible]	TOTAL
CAPITAL-42	14359.4	3947.0	112718.8	69748.9	8204.3	35892.0	2787.5	25975.0	5372.3	132.1	306546.6

	YEAR							
	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
PLAS CONS	25018.8	21448.8	11110.5	13347.5	27150.9	30348.5		
WORK CONS	10993.0	13307.1	15019.3	24570.2	40514.6	51680.2		

OTHER SUMMARY DATA BY YEAR

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
OUTPUT								
OLD TECH	108611.2	100482.5	67674.1	64207.3	37299.3	4949.0		
NEW TECH	13359.3	43902.4	101851.0	198404.7	307348.8	405066.6		
TOTAL	121970.4	147384.9	169535.1	262512.0	344648.1	410015.4		
CAPITAL STOCK								
OLD TECH	59998.0	54206.1	49059.5	44473.4	40380.4	36719.0	33436.9	
NEW TECH	5751.0	20422.1	48292.3	80699.5	160823.7	225391.6	306546.6	
TOTAL	65749.0	74628.2	97350.7	125171.8	201204.0	262110.5	339983.4	
NEW CAPITAL		15260.0	29954.3	35646.6	87437.7	78662.1	101137.4	83535.8
LABOR FORCE								
SUPPLY	55350.0	59527.0	62859.0	65004.0	59440.0	73998.0		
EMPLOYED	50987.1	52654.3	47703.2	56189.7	69479.0	73997.8		
IDLE	4352.9	5872.7	15155.4	9814.3	0.1	0.2		
PER CENT	7.9	11.5	24.1	15.9	0.0	0.0		

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unaffected, and detailed examination reveals that capital in both agricultural sectors is fully utilized. Peasant employment is limited by a lack of farm implements. We decided to attack this problem first by raising the weight on capital stock for the two agricultural sectors and then by raising the weight on peasant consumption in the third and fourth periods.

Solutions #4, #5, and #6 are reproduced in summary Table IV-13, IV-14, IV-15. The weights on capital in both agricultural sectors move up to 2.5, 2.6 and 3.0, respectively, while that on capital in Electric Power is lowered to 3.3, 3.2 and 3.2. In Solution #4, this change brings about a fall in unemployment and a rise in peasant consumption in periods three and four, when compared to Solution #3. However, Solutions #5 and #6 show no further changes in either employment or consumption. Similarly, the initial fall in the weight on capital stock in Electric Power causes a drop in the final capital stock in that sector and a rise in Producer Goods capital. Solutions #4, #5 and #6 are virtually identical, indicating that we have found a point on the edge of our convex, feasible set which is insensitive to those parameters over the ranges we have tested.

As we did not wish to raise the priority of agriculture above that of the heavy industry sector, we proceeded to the second strategy: increasing the weights on third and fourth period peasant consumption directly. In Solutions #7, #8 and #9 we raise these weights to 2.5 and 2.0, 3.0 and 3.0, and 3.2 and 3.0, respectively. The summary reports for these solutions are presented in Tables IV-16, IV-17 and IV-18.

Compared to Solution #6, Solution #7 shows little change. However, by

Table IV-16. Solution #7 Millions of Rubles (Labor Force in Thousands)

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 1102847.0

ELEMENTS OF THE OBJECTIVE FUNCTION

	SECTORS										
	AF	AL	EP	PG	CG	TC	CO	HO		GS	TOTAL
CAPITAL-42	14501.1	9945.3	112734.4	58837.8	9211.2	35029.8	2783.6	25938.8	5.5	20832.1	305839.4

	YEAR							
	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
PEAS CONS	24001.1	21451.0	12157.3	13324.4	27178.9	30348.5		
WORK CONS	10550.3	13807.2	15102.9	24529.3	40504.1	51570.0		

OTHER SUMMARY DATA BY YEAR

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
OUTPUT								
OLD TECH	108628.7	100482.9	67955.5	64207.3	37481.2	4948.8		
NEW TECH	13359.3	48902.3	103549.1	197813.5	306226.5	405068.4		
TOTAL	121987.9	149385.1	171505.5	262020.8	343707.7	410017.2		
CAPITAL STOCK								
OLD TECH	59998.0	54206.1	49059.5	44473.4	40380.4	36719.0	33436.9	
NEW TECH	5751.0	20422.1	48408.9	80386.9	160392.1	224511.9	305839.4	
TOTAL	65749.0	74628.2	97467.3	124860.2	200772.4	261230.9	339276.3	
NEW CAPITAL		15250.0	30070.0	35225.3	97289.5	78172.5	101203.9	88325.8
LABOR FORCE								
SUPPLY	55350.0	59527.0	62869.0	66004.0	69480.0	73998.0		
EMPLOYED	50989.9	52654.3	48151.1	56095.3	69479.9	73997.9		
IDLE	4360.1	6872.7	14717.9	9908.7	0.1	0.1		
PER CENT	7.9	11.5	23.4	15.0	0.0	0.0		

Table IV-17. Solution #8 Millions of Rubles (Labor Force in Thousands)

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 1215527.0

ELEMENTS OF THE OBJECTIVE FUNCTION

	SECTORS										
	AF	AL	EP	PS	CS	TC	CO	HO	TO	GS	TOTAL
CAPITAL-42	15407.0	9963.8	113570.1	58207.4	8357.5	36348.7	2600.3	25235.7	5901.0	20832.1	297423.4

	YEAR							
	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
PLAS CONS	25035.0	20858.1	11589.8	24574.3	27452.3	30351.4		
WORK CONS	10547.5	13302.5	15020.5	24275.6	39317.1	51664.9		

OTHER SUMMARY DATA BY YEAR

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
OUTPUT								
OLD TECH	108607.6	100466.5	67850.5	64207.3	38887.1	4948.8		
NEW TECH	13359.1	43006.5	103006.2	202555.3	296137.6	405022.7		
TOTAL	121966.3	149373.2	170855.7	255752.6	335024.8	409971.5		
CAPITAL STOCK								
OLD TECH	59998.0	54235.1	49059.5	44473.4	40380.4	36719.0	33436.9	
NEW TECH	5751.0	20422.1	49223.3	83352.3	154290.4	214595.8	297423.4	
TOTAL	65749.0	74628.2	97282.3	127835.5	194570.7	251314.9	330850.3	
NEW CAPITAL		15250.0	29885.8	39366.7	78771.7	73679.8	101896.0	95054.3
LABOR FORCE								
SUPPLY	55350.0	59527.0	62859.0	66004.0	69480.0	73998.0		
EMPLOYED	50986.5	52650.1	48085.5	66003.9	69479.9	73997.8		
IDLE	4363.5	6876.9	14783.5	0.1	0.1	0.2		
PER CENT	7.9	11.5	23.5	0.0	0.0	0.0		

Table IV-18. Solution #9 Millions of Rubles (Labor Force in Thousands)

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 1220309.0

ELEMENTS OF THE OBJECTIVE FUNCTION

	SECTORS										
	AF	AL	EP	PG	CG	TC	CO	HO	TO	GS	TOTAL
CAPITAL-42	15434.4	7736.4	114014.6	53397.8	8368.8	36558.9	2695.0	25435.1	555	20932.1	293305.3

	YEAR							
	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
PLAS CONS	23702.7	19367.8	25608.3	17165.5	27474.3	30351.5		
WORK CONS	10576.8	13771.2	15457.7	23429.4	38552.1	51662.6		

OTHER SUMMARY DATA BY YEAR

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
OUTPUT								
OLD TECH	108954.8	100426.2	70312.3	64207.3	39950.4	4948.9		
NEW TECH	13357.3	43917.3	111915.2	193733.1	288215.6	405031.4		
TOTAL	122214.0	149343.5	182228.5	257940.4	328166.0	409980.3		
CAPITAL STOCK								
OLD TECH	59998.0	54206.1	49058.5	44473.4	40380.4	36719.0	33436.9	
NEW TECH	5751.0	20422.1	53463.9	77490.9	152651.4	209690.0	293305.3	
TOTAL	65749.0	74628.2	102522.3	121964.3	193031.9	245408.0	325742.2	
NEW CAPITAL		15260.0	35125.7	27081.4	82324.1	70316.7	102249.2	89939.8
LABOR FORCE								
SUPPLY	55350.0	59527.0	62869.0	66004.0	59480.0	73998.0		
EMPLOYED	51023.0	52639.6	62868.9	66003.9	59162.8	73997.9		
IDLE	4327.0	5337.4	0.1	0.1	317.3	0.1		
PER CENT	7.8	11.5	0.0	0.0	0.5	0.0		

raising the third and fourth period consumption weights to 3.0 in Solution #8 we cross a threshhold, and succeed in eliminating unemployment in period four (1935-36). This results in a sharp rise in fourth period peasant consumption (13.3 to 24.7 billion rubles), at the cost of a small drop in final capital stock (339.2 to 330.9 billion rublès). Finally, in Solution #9, by pushing the weight on third period peasant consumption to 3.2, we eliminate unemployment in that period also, and raise peasant consumption in 1933-34 to reasonable levels. Note here the cost is a further drop in final capital stock of 4 billion rubles, and a loss of some fourth period consumption.

Solution #9 has most of the properties we listed above as desirable in a reference solution. It is clear, however, that Producer Goods industry as a whole would in practice require a larger stock of fixed capital than Electric Power alone, even given Lenin's stress on electrification. Our final adjustment, therefore, involves shifting the weights for capital in these two sectors to 3.1 and 3.0 respectively. The result is a balanced reference solution which deserves detailed examination.

A Balanced Reference Solution

We have now uncovered an expansion path, consistent with all the model's parameters, that exhibits a realistic balance between consumption and accumulation while at the same time drawing into use most of the economy's productive capacity. Its details are set forth in the accompanying printout, in the form of five post-solution reports. The five-page summary report lists objective function elements and displays a number of totals over all ten sectors for each of the two-year time periods: 1929 and 1930, ..., 1939 and 1940.

It then shows gross output levels produced with old-technology capital by each sector in each period, and similarly the output produced with new-technology capital by each sector in each period. Another pair of panels shows the expansion, sector by sector and period by period, of new-technology stocks of fixed capital. These are primal solution values.

The summary report continues with dual values for capital stocks, by technology, sector, and period, and for sectoral gross output levels, by period. These values can be interpreted as indicators of the extent to which a unit increase in the constraint could increase the value of the objective function in that period. Large dual valuations are a sign of bottlenecks. Finally, the summary report tabulates the deliveries to optional consumption, by sector and period, as a measure of the extent to which strain in the economy requires deviations from the standard pattern of consumption by peasants and workers.

For each period the model generates a full set of flow-table entries like those presented for 1928 and 1933 in Chapter III. These are displayed for the first period as an interindustry flow report (for the northwest quadrant), a final demand report (for the northeast quadrant), and a value added report (for the southwest quadrant). Finally, there is a resource utilization report giving details on capital and labor utilization in each sector in each period. For periods after the first, the interindustry and value added tables are not included in the accompanying material.

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 1219411.0

ELEMENTS OF THE OBJECTIVE FUNCTION

	AF	AL	EP	PS	CG	TC	CO	HO	TD	GS	TOTAL
					SECTORS						
CAPITAL-42	15304.1	9933.7	10121.4	151000.5	7995.7	32755.3	3982.7	26489.2	5572.3	20832.1	293987.1

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
					YEAR			
PEAS CONS	23303.5	17355.0	25599.5	17163.3	27520.1	30397.9		
WORK CONS	10576.0	13791.2	15449.0	23435.2	39149.4	51951.4		

OTHER SUMMARY DATA BY YEAR

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
OUTPUT								
OLD TECH	108848.6	100426.1	70303.9	64207.3	39442.6	5575.5		
NEW TECH	13359.3	48917.4	111825.4	193855.9	292351.6	400229.5		
TOTAL	122207.8	149343.4	182130.3	258073.3	331794.2	405805.0		
CAPITAL STOCK								
OLD TECH	59998.0	54205.1	49058.5	44473.4	40380.4	36719.0	33436.9	
NEW TECH	5751.0	20422.1	53418.0	77502.4	152167.3	211337.8	293987.1	
TOTAL	65749.0	74628.2	102476.4	122075.7	192547.6	248055.7	327424.0	
NEW CAPITAL		15250.0	35080.0	29235.0	81738.7	72430.6	101583.7	83220.5
LABOR FORCE								
SUPPLY	55350.0	59527.0	62869.0	66004.0	69480.0	73998.0		
EMPLOYED	51022.0	52539.5	62868.9	66003.9	69479.9	73997.8		
IDLE	4328.0	5897.4	0.1	0.1	0.1	0.2		
PER CENT	7.8	11.6	0.0	0.0	0.0	0.0		

DUAL VALUES FOR:						
LABOR	0.000	0.000	-0.077	-0.285	-0.485	-2.859
PEAS CONS	0.000	0.000	0.000	-0.070	-1.369	-4.350
WORK CONS	-0.002	-0.002	-1.013	-1.016	-1.452	-4.450
BAL OF PAY	-3.170	-2.954	-8.955	-7.562	-5.132	-9.230

SUMMARY, CONT'D

OLD TECHNOLOGY OUTPUT

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
AF	20094.1	15749.3	13962.1	11638.4	9193.7	0.0		
AL	11392.9	9710.1	8275.9	7353.6	6011.8	0.0		
EP	1191.8	1179.9	865.5	777.3	697.9	526.7		
PG	39796.9	35788.2	22506.1	20239.1	18200.4	0.0		
CG	4756.1	7555.2	8951.9	9923.9	0.0	0.0		
TC	5640.1	5250.9	3436.8	3195.1	2970.4	2761.5		
CO	9806.7	9209.8	0.0	0.0	0.0	0.0		
HO	3266.1	3016.3	2775.9	2554.6	2368.4	2187.3		
TO	5408.0	4896.1	4402.8	3986.1	0.0	0.0		
GS	7488.2	7069.9	5115.7	4829.3	0.0	0.0		

NEW TECHNOLOGY OUTPUT

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
AF	3093.6	8823.4	24919.6	27916.4	32424.9	48805.0		
AL	2051.1	5275.0	5789.7	5750.5	15443.8	22601.4		
EP	335.1	1559.1	3580.9	6501.1	10189.8	13800.0		
PG	2234.5	17312.3	36016.9	72703.1	103260.2	149895.9		
CG	2504.0	0.0	5598.3	7755.5	38674.3	48205.5		
TC	230.2	0.0	2225.4	4940.0	8803.4	11595.0		
CO	1712.6	11379.6	25530.8	50596.7	43598.7	55259.4		
HO	340.5	750.3	0.0	808.5	4594.9	6578.9		
TO	635.5	773.2	773.9	6803.5	13038.5	22760.3		
GS	222.2	3043.6	7401.1	10090.7	17323.2	19725.4		

SUMMARY, CONT'D

NEW TECHNOLOGY CAPITAL STOCK

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
AF	979.0	3530.1	9935.4	8979.6	11368.0	17898.3	15304.3	
AL	954.0	3156.8	2692.9	2836.5	9224.7	11645.1	9933.7	
EP	248.0	603.0	3553.3	5503.6	8651.7	11255.1	10121.4	
PG	524.0	3030.2	10890.7	20100.3	26731.1	65107.2	161000.5	
CS	452.0	1108.4	1039.3	1606.5	9345.5	8785.3	7995.7	
TC	649.0	2698.2	7889.5	16756.6	28787.0	35240.1	32755.3	
CO	131.0	670.5	2549.7	4615.7	3856.8	4766.4	3982.7	
HO	1404.0	3850.7	3597.8	3334.1	25740.6	28504.4	26489.2	
TD	164.0	221.7	199.7	2431.2	5711.7	6186.0	5572.3	
GS	246.0	1442.5	11120.3	11438.4	22749.3	21950.1	20832.1	

NEW CAPITAL STOCK INCREMENTS

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
AF		2793.0	6831.4	484.1	3689.9	8177.9	0.0	5958.4
AL		2343.0	0.0	539.3	6805.1	3776.0	0.0	3734.0
EP		380.0	3011.1	2308.2	3702.5	3474.9	0.0	3259.5
PG		2552.0	8115.3	10170.6	8387.6	40712.3	101583.7	43077.0
CS		697.0	0.0	599.4	7884.4	278.9	0.0	2311.1
TC		2095.0	5381.5	9423.4	13211.9	8482.9	0.0	9352.9
CO		561.0	1989.5	2485.2	0.0	1543.7	0.0	1773.6
HO		2556.0	0.0	0.0	22642.2	4583.7	0.0	7082.8
TD		74.0	0.0	2251.2	3521.8	1041.0	0.0	1705.2
GS		1209.0	9751.3	884.4	11893.5	359.3	0.0	5266.2

SUMMARY, CONT'D

OLD TECHNOLOGY CAPITAL CAPACITY CONSTRAINT DUAL

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
AF	-5.340	-4.375	-3.507	-2.737	0.000	0.000		
AL	-1.986	-1.593	-1.211	-2.262	-0.686	0.000		
EP	0.000	-40.416	-5.000	-5.309	-3.991	-0.317		
PG	-16.627	-10.035	-13.735	-8.736	-3.762	0.000		
CG	0.000	0.000	0.000	-2.829	0.000	0.000		
TC	-0.649	-0.437	-11.205	-7.327	-2.314	-0.419		
CO	0.000	-658.424	0.000	0.000	0.000	0.000		
HO	-0.349	-0.288	-0.193	-0.218	-0.590	-2.152		
TD	-27.539	-22.602	-12.846	-14.297	0.000	0.000		
GS	0.000	-0.881	-19.804	-11.020	0.000	0.000		

NEW TECHNOLOGY CAPITAL CAPACITY CONSTRAINT DUAL

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
AF	-5.985	-4.881	-3.472	-3.165	-2.603	-0.844		
AL	-2.596	-1.820	-0.879	-2.541	-1.153	-0.509		
EP	-0.004	-55.283	-4.355	-3.922	-2.946	-0.592		
PG	-5.923	0.000	-8.820	-5.779	-2.746	0.000		
CG	-0.967	0.000	-3.513	-5.974	-2.295	-1.181		
TC	-0.055	0.000	-9.905	-6.475	-2.120	-1.128		
CO	-13.102	-722.973	-1.715	-7.169	0.000	-1.970		
HO	-0.425	-0.350	0.000	-0.094	-0.851	-3.601		
TD	-9.427	-7.746	-6.183	-6.685	-1.207	-3.991		
GS	-0.207	0.000	-18.536	-10.883	-0.510	-3.100		

SUMMARY, CONT'D

DISTRIBUTION RELATIONSHIP DUAL VALUE

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
AF	-2.580	-2.124	-2.178	-2.237	-3.181	-8.518		
AL	-2.580	-2.124	-2.178	-2.872	-2.599	-5.741		
EP	-0.757	-20.327	-9.525	-7.390	-4.274	-2.393		
PG	-2.580	-2.124	-7.456	-5.315	-2.859	-3.089		
CG	-3.170	-2.954	-8.856	-7.662	-5.132	-9.230		
TC	-2.580	-2.124	-37.000	-25.026	-10.015	-9.571		
CD	-2.181	-37.623	-2.951	-2.782	-1.544	-3.172		
HO	-2.580	-2.124	-2.178	-2.237	-4.660	-15.742		
TD	-2.580	-2.124	-2.178	-2.237	-0.807	-2.413		
GS	-1.065	-2.912	-24.588	-15.293	-2.809	-7.611		

OPTIONAL CONSUMPTION

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
AF	6586.0	7082.1	14852.8	13044.0	0.0	0.0		
AL	8611.8	10748.7	3928.2	0.0	0.0	0.0		
EP	0.0	0.0	0.0	0.0	0.0	0.0		
PG	5231.2	3099.9	0.0	0.0	0.0	0.0		
CG	0.0	0.0	0.0	0.0	0.0	0.0		
TC	1858.6	512.5	0.0	0.0	0.0	0.0		
CD	0.0	0.0	0.0	0.0	0.0	0.0		
HO	3274.7	3429.3	728.2	1151.0	0.0	0.0		
TD	5379.3	4078.5	1015.0	6104.7	3333.5	4118.0		
GS	0.0	0.0	0.0	0.0	0.0	0.0		

MAY 22, 1980. BASELINE SOLUTION FOR PARSING THE SOVIET EXPERIENCE.
ALPHA=BETA=555577. ALEPH=BETH=1155.95.95. FINAL K,B ADJUSTMENTS.
YEAR IS 1930

INTERINDUSTRY FLOW REPORT

DELIVERING SECTORS	RECEIVING SECTORS AF	AL	EP	PG	CG	TC	CO	HO	TD	GS	IIO	FO
AF	3250.0	5102.5	0.0	1192.1	2744.0	275.0	1906.0	0.0	0.0	147.2	15626.9	7560.8
AL	711.3	275.0	0.0	0.0	427.0	0.0	0.0	0.0	0.0	103.2	1516.8	11927.2
EP	0.0	22.7	172.7	607.0	150.1	53.0	0.0	0.0	0.0	521.4	1526.9	0.0
PG	359.6	253.2	231.4	15159.1	3638.0	1928.7	5836.9	392.0	393.6	269.1	28442.6	13588.8
CG	473.9	350.7	0.0	2122.4	687.9	450.9	30.4	0.0	95.0	1735.8	5946.9	1313.1
TC	0.0	0.0	172.0	2775.4	320.3	332.0	0.0	0.0	0.0	352.2	3952.9	1925.3
CO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11519.3
HO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3606.5
TD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6043.5
GS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7710.4
IIO	4804.8	7004.4	575.1	21857.2	7967.4	3039.5	7773.3	382.9	470.6	3128.8	57013.0	
VA	18382.9	6439.6	950.8	20174.3	-707.4	2838.7	3745.1	3223.7	5564.8	4581.6	0.0	65195.0
GVO	23187.7	13444.0	1526.9	42031.4	7260.1	5878.2	11519.3	3606.5	6043.5	7710.4	0.0	0.0

TOTAL GVO = 122207.8

FINAL DEMAND REPORT

	DELIVERING SECTORS											
	AF	AL	EP	PG	CG	TC	CO	HO	TO	GS	TOTAL	DUAL
INTERINDUSTRY DEMAND												
	15626.9	1516.8	1525.9	23442.6	5946.9	3952.9	0.0	0.0	0.0	0.0	57013.0	
CONSUMPTION												
PEASANTS	394.9	828.3	0.0	9.6	565.3	29.8	0.0	194.6	357.8	0.0	2380.3	0.000
WORKERS	101.7	153.2	0.0	8.6	313.5	36.9	0.0	137.2	305.4	0.0	1057.6	-0.002
OPTIONAL	6586.0	8611.8	0.0	5231.2	0.0	1858.6	0.0	3274.7	5379.3	0.0	30941.6	
TOTAL	7082.6	9593.4	0.0	5249.3	878.8	1925.3	0.0	3606.5	6043.5	0.0	34379.5	
INVESTMENT												
FIRST YEAR	0.0	304.0	0.0	3553.9	0.0	0.0	4555.0	0.0	0.0	0.0	8412.9	
2ND YEAR	0.0	1562.2	0.0	4599.8	0.0	0.0	5438.3	0.0	0.0	0.0	11600.4	
TOTAL	0.0	1355.2	0.0	8153.7	0.0	0.0	9993.4	0.0	0.0	0.0	20013.2	
STOCK GROWTH												
OLD TECH	376.2	0.0	0.0	216.9	155.6	0.0	1299.0	0.0	0.0	0.0	2047.7	
NEW TECH	54.7	0.0	0.0	40.7	438.8	0.0	227.0	0.0	0.0	0.0	761.1	
TOTAL	430.9	0.0	0.0	257.6	594.4	0.0	1526.0	0.0	0.0	0.0	2808.8	
GOVERNMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7710.4	7710.4	
FOREIGN TRADE												
EXPORTS	177.2	546.4	0.0	848.8	136.0	0.0	0.0	0.0	0.0	0.0	1708.4	
IMPORTS:												
OLD TECH	122.4	73.8	0.0	868.0	38.6	0.0	0.0	0.0	0.0	0.0	1102.7	
NEW TECH	7.5	5.0	0.0	52.6	21.3	0.0	0.0	0.0	0.0	0.0	86.5	
OPTIONAL	0.0	0.0	0.0	0.0	236.2	0.0	0.0	0.0	0.0	0.0	236.2	
TOTAL	129.9	78.8	0.0	920.6	296.1	0.0	0.0	0.0	0.0	0.0	1425.4	
NET EXPORT	47.3	467.6	0.0	-71.8	-160.1	0.0	0.0	0.0	0.0	0.0	283.0	-3.170
FOREIGN TRADE CREDITS										-283.0		
FINAL DEMAND TOTALS												
	7560.8	11927.2	0.0	13588.8	1313.1	1925.3	11519.3	3606.5	6043.5	7710.4	65195.0	
GROSS VALUE OF OUTPUT												
OLD TECH	20094.1	11392.9	1191.8	39796.9	4756.1	5648.1	9806.7	3266.1	5408.0	7488.2	108848.6	
NEW TECH	3093.6	2051.1	335.1	2234.5	2504.0	230.2	1712.6	340.5	635.5	222.2	13359.3	
TOTAL	23187.7	13444.0	1526.9	42031.4	7260.1	5878.2	11519.3	3606.5	6043.5	7710.4	122207.8	
DUAL VALUES OF DISTRIBUTION CONSTRAINTS												
	-2.580	-2.580	-0.759	-2.580	-3.170	-2.580	-2.181	-2.580	-2.580	-1.065		

ALPHA=BETA=555577. ALEPH=BETH=1155.95.95. FINAL C,B ADJUSTMENTS.
YEAR IS 1930

VALUE ADDED REPORT

	PRODUCING SECTORS										
	AF	AL	EP	PG	CG	TC	CO	HO	TD	GS	TOTAL
INT INPUTS	4804.8	7004.4	576.1	21857.2	7967.4	3039.5	7773.3	382.9	478.6	3128.8	57013.0
WAGES											
OLD TECH	15838.0	1754.0	57.3	4510.9	2437.5	3596.1	2624.5	603.4	1687.1	4548.6	37657.9
NEW TECH	1472.8	201.8	5.6	185.5	527.8	50.8	158.2	30.1	73.7	44.3	2760.6
TOTAL	17310.8	1955.3	63.4	4696.4	2965.3	3646.9	2792.8	633.6	1760.8	4592.9	40418.5
DEPRECIATION											
OLD TECH	1249.7	1035.5	58.1	288.2	246.5	770.6	101.3	1689.1	43.8	309.0	5791.9
NEW TECH	141.9	140.2	25.0	45.8	40.6	45.8	21.5	99.3	15.3	12.5	588.9
TOTAL	1391.6	1175.7	83.0	334.0	287.2	816.4	122.8	1788.4	60.1	321.5	6380.8
PROF/SUBS	-319.5	3308.1	804.3	15143.9	-3959.8	-1524.5	830.5	901.7	3743.9	-332.8	18395.7
GNP	18392.9	5439.6	950.8	20174.3	-707.4	2838.7	3746.1	3223.7	5564.8	4581.5	65195.0
GVO	23187.7	13444.0	1526.9	42031.4	7260.1	5878.2	11519.3	3606.5	6043.5	7710.4	122207.8

ALPHA=BETA=555577. ALEPH=BETH=1155.95.95. FINAL K,B ADJUSTMENTS.
YEAR IS 1930

RESOURCE UTILIZATION REPORT

	PRODUCING SECTORS										
	AF	AL	EP	PG	CG	TC	CO	HO	TO	GS	TOTAL
CAPITAL STOCK											
OLD TECHNOLOGY											
STOCK	7509.0	7011.0	569.0	2861.0	2485.0	10959.0	535.0	22096.0	463.0	5519.0	59998.0
UTILIZED	7509.0	7011.0	516.1	2861.0	870.5	10959.0	462.9	22086.0	463.0	5518.2	59256.7
PERCENT	100.0	100.0	90.7	100.0	35.0	100.0	86.4	100.0	100.0	100.0	97.1
CAPACITY CONSTRAINT											
DUAL VALUE	-5.340	-1.035	0.000	-16.627	0.000	-0.649	0.000	-0.349	-27.539	0.000	
NEW TECHNOLOGY											
STOCK	979.0	954.0	248.0	524.0	452.0	649.0	131.0	1404.0	164.0	246.0	5751.0
AVAILABLE	979.0	954.0	248.0	524.0	452.0	649.0	131.0	1404.0	164.0	246.0	
UTILIZED	979.0	954.0	248.0	524.0	452.0	649.0	131.0	1404.0	164.0	246.0	5751.0
PERCENT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
CAPACITY CONSTRAINT											
DUAL VALUE	-5.785	-2.595	-0.034	-5.923	-0.967	-0.055	-13.102	-0.425	-9.427	-0.207	
LABOR FORCE											
OLD TECH	31752.2	3516.4	20.0	2396.1	1294.8	1931.1	1582.7	726.9	1019.4	2807.4	47047.0
NEW TECH	2952.8	404.5	1.9	98.5	280.3	27.3	101.5	36.3	44.5	27.3	3975.0
TOTAL	34705.0	3920.9	22.0	2494.6	1575.1	1958.4	1684.2	763.2	1063.9	2834.8	51022.0

TOTAL LABOR SUPPLY: 55350 EMPLOYED: 51022 PERCENT EMPLOYED: 92.2 DUAL VALUE: 0.000

FINAL DEMAND REPORT

DELIVERING SECTORS

	AF	AL	EP	PG	CG	TC	CD	HO	TD	GS	TOTAL	DUAL
INTERINDUSTRY DEMAND												
	17480.0	1708.7	2739.0	34643.0	7038.4	4665.0	0.0	0.0	0.0	0.0	68275.1	
CONSUMPTION												
PEASANTS	321.3	673.9	0.0	7.8	459.9	24.3	0.0	158.3	291.	0.0	1936.6	0.000
WORKERS	132.6	199.8	0.0	11.2	408.8	48.1	0.0	179.0	399.	0.0	1379.1	-0.002
OPTIONAL	7082.3	10749.7	0.0	3089.9	0.0	512.5	0.0	3429.3	4979.	0.0	29841.4	
TOTAL	7536.2	11622.4	0.0	3108.9	868.7	584.9	0.0	3766.6	5669.	0.0	33157.1	
INVESTMENT												
FIRST YEAR	0.0	106.4	0.0	3482.3	0.0	0.0	3421.8	0.0	0.	0.0	7010.6	
2ND YEAR	0.0	962.5	0.0	11265.1	0.0	0.0	14439.5	0.0	0.0	0.0	26667.1	
TOTAL	0.0	1069.0	0.0	14747.4	0.0	0.0	17851.3	0.0	0.0	0.0	33677.7	
STOCK GROWTH												
OLD TECH	313.6	0.0	0.0	195.0	247.2	0.0	1219.9	0.0	0.0	0.0	1975.7	
NEW TECH	156.0	0.0	0.0	315.1	0.0	0.0	1508.1	0.0	0.0	0.0	1979.2	
TOTAL	469.6	0.0	0.0	510.1	247.2	0.0	2728.1	0.0	0.0	0.0	3955.0	
GOVERNMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10113.6	10113.6	
FOREIGN TRADE												
EXPORTS	210.8	661.6	0.0	1279.2	184.0	0.0	0.0	0.0	0.0	0.0	2335.6	
IMPORTS:												
OLD TECH	102.0	62.9	0.0	780.5	61.3	0.0	0.0	0.0	0.0	0.0	1006.7	
NEW TECH	21.4	12.8	0.0	407.7	0.0	0.0	0.0	0.0	0.0	0.0	442.0	
OPTIONAL	0.0	0.0	0.0	0.0	721.9	0.0	0.0	0.0	0.0	0.0	721.9	
TOTAL	123.4	75.7	0.0	1188.2	783.2	0.0	0.0	0.0	0.0	0.0	2170.6	
NET EXPORT	87.4	585.9	0.0	91.0	-599.2	0.0	0.0	0.0	0.0	0.0	165.0	-2.954
FOREIGN TRADE CREDITS										-165.0		
FINAL DEMAND TOTALS												
	8093.2	13277.3	0.0	18457.5	516.8	584.9	20579.4	3766.6	5669.3	10113.6	81068.4	
GROSS VALUE OF OUTPUT												
OLD TECH	16749.8	9710.1	1179.9	35788.2	7555.2	5250.9	9209.8	3016.3	4896.1	7069.9	100426.1	
NEW TECH	8823.4	5275.9	1559.1	17312.3	0.0	0.0	11379.6	750.3	773.2	3043.6	48917.4	
TOTAL	25573.2	14986.0	2739.0	53100.5	7555.2	5250.9	20589.4	3766.6	5669.3	10113.5	149343.4	
DUAL VALUES OF DISTRIBUTION CONSTRAINTS												
	-2.124	-2.124	-20.327	-2.124	-2.954	-2.124	-37.623	-2.124	-2.124	-2.912		

ALPHA=BETA=555577. ALEPH=BETH=1155.95.95. FINAL K,B ADJUSTMENTS.
YEAR 15-1932

RESOURCE UTILIZATION REPORT

	PRODUCING SECTORS AF	AL	EP	PG	CG	TC	CO	HO	TO	GS	TOTAL
CAPITAL STOCK											
OLD TECHNOLOGY											
STOCK	6259.3	5975.5	510.9	2572.8	2238.5	10188.4	434.7	20396.9	419.2	5210.0	54206.1
UTILIZED	6259.3	5975.5	510.9	2572.8	1392.8	10188.4	434.7	20396.9	419.2	5210.0	53350.4
PERCENT	100.0	100.0	100.0	100.0	61.8	100.0	100.0	100.0	100.0	100.0	98.4
CAPACITY CONSTRAINT											
DUAL VALUE	-4.375	-1.593	-40.416	-10.036	0.000	-0.437	-658.424	-0.288	-22.602	-0.881	
NEW TECHNOLOGY											
STOCK	3630.1	3156.9	603.0	3030.2	1108.4	2698.2	670.5	3860.7	221.7	1442.5	20422.1
AVAILABLE	2792.2	2453.9	489.0	2264.6	899.3	2069.7	502.2	3093.9	199.5	1079.8	
UTILIZED	2792.2	2453.9	489.0	2196.4	0.0	0.0	502.2	3093.9	199.5	1078.7	12805.9
PERCENT	100.0	100.0	100.0	97.0	0.0	0.0	100.0	100.0	100.0	99.9	80.8
CAPACITY CONSTRAINT											
DUAL VALUE	-4.081	-1.820	-55.283	0.000	0.000	0.000	-722.978	-0.350	-7.746	0.000	
LABOR FORCE											
OLD TECH	26457.7	2997.0	19.8	2154.8	2056.8	1795.3	1486.4	671.3	922.9	2650.6	41222.5
NEW TECH	8421.6	1040.5	9.1	763.3	0.0	0.0	674.2	80.0	54.2	374.2	11417.0
TOTAL	34889.3	4037.5	28.9	2918.1	2056.8	1795.3	2160.6	751.3	977.1	3024.9	52639.6

TOTAL LABOR SUPPLY: 59527 EMPLOYED: 52640 PERCENT EMPLOYED: 88.4 DUAL VALUE: 0.000

ALPHA=BETA=555577. ALEPH=BETH=1155.95.95. FINAL K,B ADJUSTMENTS.
YEAR 15 1934

FINAL DEMAND REPORT

DELIVERING SECTORS

	AF	AL	FP	PG	CG	TC	CD	HD	TD	GS	TOTAL	DUAL
INTERINDUSTRY DEMAND												
	20361.9	2282.4	4445.4	39154.0	8783.5	5232.2	0.0	0.0	0.0	0.0	80260.3	
CONSUMPTION												
PEASANTS	2123.3	4454.2	0.0	51.7	3039.8	160.4	0.0	1046.4	1923.9	0.0	12799.6	0.000
WORKERS	742.9	1119.2	0.0	62.6	2289.8	269.6	0.0	1002.3	2238.0	0.0	7724.5	-1.013
OPTIONAL	14852.8	3928.2	0.0	0.0	0.0	0.0	0.0	728.2	1015.0	0.0	20524.2	
TOTAL	17719.1	9501.6	0.0	114.3	5329.7	430.0	0.0	2776.9	5175.9	0.0	41048.3	
INVESTMENT												
FIRST YEAR	0.0	1235.3	0.0	7068.7	0.0	0.0	11297.2	0.0	0.0	0.0	19601.3	
2ND YEAR	0.0	337.2	0.0	11037.2	0.0	0.0	10849.9	0.0	0.0	0.0	22224.4	
TOTAL	0.0	1572.5	0.0	18105.9	0.0	0.0	22147.2	0.0	0.0	0.0	41825.6	
STOCK GROWTH												
OLD TECH	261.4	0.0	0.0	122.7	293.2	0.0	0.0	0.0	0.0	0.0	677.3	
NEW TECH	440.6	0.0	0.0	655.5	979.2	0.0	3383.6	0.0	0.0	0.0	5458.9	
TOTAL	701.9	0.0	0.0	778.2	1272.5	0.0	3383.6	0.0	0.0	0.0	6136.2	
GOVERNMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12516.8	12516.8	
FOREIGN TRADE												
EXPORTS	244.4	776.8	0.0	1709.6	232.0	0.0	0.0	0.0	0.0	0.0	2962.8	
IMPORTS:												
OLD TECH	85.0	53.5	0.0	490.9	72.7	0.0	0.0	0.0	0.0	0.0	702.2	
NEW TECH	60.6	14.1	0.0	848.2	47.6	0.0	0.0	0.0	0.0	0.0	970.4	
OPTIONAL	0.0	0.0	0.0	0.0	947.2	0.0	0.0	0.0	0.0	0.0	947.2	
TOTAL	145.6	67.7	0.0	1339.1	1067.5	0.0	0.0	0.0	0.0	0.0	2619.8	
NET EXPORT	98.8	709.1	0.0	370.5	-835.5	0.0	0.0	0.0	0.0	0.0	343.0	-8.856
FOREIGN TRADE CREDITS										-343.0		
FINAL DEMAND TOTALS												
	18519.9	11783.3	0.0	19369.0	5766.7	430.0	25530.8	2776.9	5175.8	12516.8	101869.9	
GROSS VALUE OF OUTPUT												
OLD TECH	13962.1	8275.9	865.6	22506.1	8961.9	3436.8	0.0	2776.9	4402.9	5115.7	70303.9	
NEW TECH	24919.5	5789.7	3580.9	36016.9	5588.3	2225.4	25530.8	0.0	773.9	7401.1	111826.4	
TOTAL	38881.8	14065.6	4446.4	58523.0	14550.2	5662.2	25530.8	2776.9	5176.8	12516.8	182130.3	
DUAL VALUES OF DISTRIBUTION CONSTRAINTS												
	-2.178	-2.179	-9.626	-7.456	-8.856	-37.000	-2.961	-2.178	-2.178	-24.589		

YEAR IS 1934

RESOURCE UTILIZATION REPORT

PRODUCING SECTORS

	AF	AL	EP	PG	CG	TC	CO	HO	TD	GS	TOTAL
CAPITAL STOCK											
OLD TECHNOLOGY											
STOCK	5217.5	5092.9	458.8	2313.7	2016.4	9471.9	352.6	18836.9	379.5	4918.3	49058.5
UTILIZED	5217.5	5092.9	458.8	2313.6	1640.3	9471.9	0.0	18836.9	379.5	4918.3	48329.7
PERCENT	100.0	100.0	100.0	100.0	81.3	100.0	0.0	100.0	100.0	100.0	98.5
CAPACITY CONSTRAINT											
DUAL VALUE	-3.607	-1.211	-5.993	-13.735	0.000	-11.205	0.000	-0.193	-12.346	-19.804	
NEW TECHNOLOGY											
STOCK	9935.4	2692.9	3553.3	10880.7	1008.8	7889.5	2549.7	3587.8	199.7	11120.3	53418.0
AVAILABLE	7886.0	2692.9	2650.0	8446.1	1008.8	6275.0	1952.8	3587.8	199.7	8194.9	
UTILIZED	7886.0	2692.9	2650.0	8446.1	1008.8	6275.0	1952.9	0.0	199.7	8194.9	39306.2
PERCENT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	91.6
CAPACITY CONSTRAINT											
DUAL VALUE	-3.472	-0.893	-4.355	-8.820	-3.513	-9.905	-1.716	0.000	-6.183	-18.585	
LABOR FORCE											
OLD TECH	22062.7	2554.4	14.5	1355.1	2439.7	1175.0	0.0	618.0	829.9	1918.0	32967.3
NEW TECH	23784.9	1141.9	20.9	1588.0	625.6	263.8	1512.6	0.0	54.3	910.0	29901.7
TOTAL	45847.5	3696.2	35.4	2943.1	3065.3	1438.8	1512.6	618.0	884.2	2827.9	62869.0

TOTAL LABOR SUPPLY: 62869 EMPLOYED: 62869 PERCENT EMPLOYED: 100.0 DUAL VALUE: -0.077

ALPHA-BETA=555577. ALEPH=BETH=1155.95.95. FINAL K,B ADJUSTMENTS.
YEAR IS-1936

FINAL DEMAND REPORT

	DELIVERING SECTORS AF	AL	EP	PG	CG	TC	CO	HO	TO	GS	TOTAL	DUAL
INTERINDUSTRY DEMAND												
	23109.4	2415.1	7278.4	60649.1	11441.9	7618.5	0.0	0.0	0.0	0.0	112512.5	
CONSUMPTION												
PEASANTS	1423.6	2986.3	0.0	34.7	2038.1	107.5	0.0	701.5	1289.8	0.0	8581.5	-0.070
WORKERS	1127.0	1697.8	0.0	94.9	3473.7	409.0	0.0	1520.5	3395.1	0.0	11718.1	-1.016
OPTIONAL	13044.0	0.0	0.0	0.0	0.0	0.0	0.0	1151.0	6104.7	0.0	20299.7	
TOTAL	15594.7	4684.2	0.0	129.6	5511.8	516.5	0.0	3373.1	10789.6	0.0	40599.4	
INVESTMENT												
FIRST YEAR	0.0	958.3	0.0	8333.6	0.0	0.0	8077.9	0.0	0.0	0.0	17369.7	
2ND YEAR	0.0	3914.3	0.0	22409.9	0.0	0.0	35813.2	0.0	0.0	0.0	62137.4	
TOTAL	0.0	4872.5	0.0	30743.5	0.0	0.0	43891.1	0.0	0.0	0.0	79507.0	
STOCK GROWTH												
OLD TECH	217.9	0.0	0.0	110.3	324.7	0.0	0.0	0.0	0.0	0.0	652.9	
NEW TECH	493.6	0.0	0.0	1323.2	1359.0	0.0	6705.6	0.0	0.0	0.0	9881.3	
TOTAL	711.4	0.0	0.0	1433.5	1683.7	0.0	6705.6	0.0	0.0	0.0	10534.2	
GOVERNMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14920.0	14920.0	
FOREIGN TRADE												
EXPORTS	278.0	892.0	0.0	2140.0	280.0	0.0	0.0	0.0	0.0	0.0	3590.0	
IMPORTS:												
OLD TECH	70.9	45.7	0.0	441.4	80.5	0.0	0.0	0.0	0.0	0.0	638.5	
NEW TECH	67.8	14.0	0.0	1712.2	66.1	0.0	0.0	0.0	0.0	0.0	1860.0	
OPTIONAL	0.0	0.0	0.0	0.0	1091.5	0.0	0.0	0.0	0.0	0.0	1091.5	
TOTAL	138.7	59.7	0.0	2153.6	1238.0	0.0	0.0	0.0	0.0	0.0	3590.0	
NET EXPORT	139.3	832.3	0.0	-13.6	-958.0	0.0	0.0	0.0	0.0	0.0	0.0	-7.662
FOREIGN TRADE CREDITS										0.0		
FINAL DEMAND TOTALS												
	16445.4	10389.0	0.0	32293.0	6237.5	516.5	50596.7	3373.1	10789.6	14920.0	145560.7	
GROSS VALUE OF OUTPUT												
OLD TECH	11638.4	7053.6	777.3	20239.1	9923.9	3195.1	0.0	2564.6	3986.1	4829.3	64207.3	
NEW TECH	27916.4	5750.5	6501.1	72703.1	7755.5	4940.0	50596.7	808.5	6803.5	10090.7	193865.9	
TOTAL	39554.9	12804.1	7278.4	92942.2	17679.4	8135.1	50596.7	3373.1	10789.6	14920.0	258073.3	
DUAL VALUES OF DISTRIBUTION CONSTRAINTS												
	-2.237	-2.872	-7.390	-5.315	-7.662	-25.025	-2.782	-2.237	-2.237	-15.293		

YEAR IS 1936

RESOURCE UTILIZATION REPORT

PRODUCING SECTORS

	AF	AL	EP	PG	CG	TC	CO	HO	TO	GS	TOTAL
CAPITAL STOCK											
OLD TECHNOLOGY											
STOCK	4349.2	4340.7	412.0	2080.6	1816.3	8805.8	286.0	17396.3	343.6	4642.9	44473.4
UTILIZED	4349.2	4340.7	417.0	2080.6	1816.3	8805.8	0.0	17376.3	343.6	4642.9	44187.3
PERCENT	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	99.4
CAPACITY CONSTRAINT											
DUAL VALUE	-2.737	-2.262	-5.339	-8.736	-2.829	-7.327	0.000	-0.218	-14.297	-11.020	
NEW TECHNOLOGY											
STOCK	8979.6	2336.5	5503.6	20100.3	1606.5	16756.6	4615.7	3334.1	2431.2	11438.4	77602.4
AVAILABLE	8834.3	2674.7	4811.2	17049.1	1400.0	13929.6	3870.1	3334.1	1755.8	11173.1	
UTILIZED	8834.3	2674.7	4811.2	17049.1	1400.0	13929.6	3870.2	3334.1	1755.8	11173.1	68831.9
PERCENT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
CAPACITY CONSTRAINT											
DUAL VALUE	-3.165	-2.541	-3.922	-5.779	-5.974	-6.475	-7.169	-0.394	-6.685	-10.883	
LABOR FORCE											
OLD TECH	18390.8	2177.1	13.0	1218.6	2701.6	1092.4	0.0	570.7	751.4	1810.6	28726.2
NEW TECH	26645.2	1134.1	37.8	3205.5	868.3	585.5	2997.6	86.2	476.9	1240.7	37277.8
TOTAL	45036.0	3311.2	50.9	4424.1	3569.9	1677.9	2997.6	656.9	1228.3	3051.3	66003.9

TOTAL LABOR SUPPLY: 66004 EMPLOYED: 66004 PERCENT EMPLOYED: 100.0 DUAL VALUE: -0.286

FINAL DEMAND REPORT

DELIVERING SECTORS

	AF	AL	EP	PG	CG	TC	CO	HO	TO	GS	TOTAL	DUAL
INTERINDUSTRY DEMAND												
	32782.2	3002.5	10897.9	90768.9	15512.5	10148.2	0.0	0.0	0.0	0.0	153102.0	
CONSUMPTION												
PEASANTS	4337.0	9097.9	0.0	105.6	6209.0	327.6	0.0	2137.3	3927.	0.0	26143.8	-1.369
WORKERS	3577.1	5398.7	0.0	301.3	11025.2	1298.0	0.0	4826.0	10775.	0.0	37191.9	-1.452
OPTIONAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3333.	0.0	3333.5	
TOTAL	7914.2	14486.6	0.0	406.9	17234.1	1525.5	0.0	5963.3	18033.	0.0	66669.1	
INVESTMENT												
FIRST YEAR	0.0	0.0	0.0	12149.4	0.0	0.0	12210.4	0.0	0.	0.0	24359.8	
2ND YEAR	0.0	3035.8	0.0	26415.0	0.0	0.0	25610.2	0.0	0.	0.0	55061.0	
TOTAL	0.0	3035.3	0.0	38564.4	0.0	0.0	37820.6	0.0	0.0	0.0	79420.7	
STOCK GROWTH												
OLD TECH	172.1	0.0	0.0	99.2	0.0	0.0	0.0	0.0	0.0	0.0	271.3	
NEW TECH	573.3	0.0	0.0	1879.3	6776.9	0.0	5778.1	0.0	0.0	0.0	15007.6	
TOTAL	745.4	0.0	0.0	1978.5	6776.9	0.0	5778.1	0.0	0.0	0.0	15278.9	
GOVERNMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17323.2	17323.2	
FOREIGN TRADE												
EXPORTS	311.6	1007.2	0.0	2570.4	328.0	0.0	0.0	0.0	0.0	0.0	4217.2	
IMPORTS:												
OLD TECH	56.0	39.0	0.0	397.0	0.0	0.0	0.0	0.0	0.0	0.0	491.9	
NEW TECH	78.8	37.5	0.0	2431.8	329.5	0.0	0.0	0.0	0.0	0.0	2877.6	
OPTIONAL	0.0	0.0	0.0	0.0	847.7	0.0	0.0	0.0	0.0	0.0	847.7	
TOTAL	134.8	76.5	0.0	2828.7	1177.2	0.0	0.0	0.0	0.0	0.0	4217.2	
NET EXPORT	176.8	930.7	0.0	-258.3	-849.2	0.0	0.0	0.0	0.0	0.0	0.0	-5.132
FOREIGN TRADE CREDITS										0.0		
FINAL DEMAND TOTALS												
	8836.4	18453.1	0.0	40691.6	23161.8	1625.6	43598.7	6963.3	18038.5	17323.2	178692.1	
GROSS VALUE OF OUTPUT												
OLD TECH	9193.7	6011.8	697.9	18200.4	0.0	2970.4	0.0	2368.4	0.0	0.0	39442.6	
NEW TECH	32424.9	15443.3	10199.9	103260.2	38674.3	8803.4	43598.7	4594.9	18038.5	17323.2	292351.6	
TOTAL	41618.6	21455.6	10887.8	121450.6	38674.3	11773.8	43598.7	6963.3	18038.5	17323.2	331794.1	
DUAL VALUES OF DISTRIBUTION CONSTRAINTS												
	-3.181	-2.539	-4.274	-2.859	-5.132	-10.015	-1.544	-4.660	-0.807	-2.809		

ALPHA=BETA=555577. ALEPH=BETH=1155.95.95. FINAL K,B ADJUSTMENTS.
YEAR IS 1938

RESOURCE UTILIZATION REPORT

PRODUCING SECTORS

	AF	AL	EP	PG	CG	TC	CO	HO	TD	GS	TOTAL
CAPITAL STOCK											
OLD TECHNOLOGY											
STOCK	3625.4	3699.6	369.9	1871.0	1636.1	8186.5	232.0	15065.8	311.1	4382.9	40380.4
UTILIZED	3435.6	3699.5	369.9	1871.0	0.0	8186.6	0.0	16065.8	0.0	0.0	33628.5
PERCENT	94.8	100.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0	0.0	83.3
CAPACITY CONSTRAINT											
DUAL VALUE	0.000	-0.695	-3.991	-3.762	0.000	-2.314	0.000	-0.580	0.000	0.000	
NEW TECHNOLOGY											
STOCK	11368.0	9224.7	8651.7	25731.1	9346.5	28787.0	3856.8	25740.6	5711.7	22749.3	152167.3
AVAILABLE	10261.0	7183.2	7541.0	24214.8	6981.2	24823.4	3856.8	18947.9	4655.2	19181.3	
UTILIZED	10261.0	7183.2	7541.0	24214.8	6981.2	24823.4	3334.9	18947.9	4655.2	19181.3	127123.8
PERCENT	100.0	100.0	100.0	100.0	100.0	100.0	86.5	100.0	100.0	100.0	99.6
CAPACITY CONSTRAINT											
DUAL VALUE	-2.603	-1.153	-2.955	-2.746	-2.295	-2.120	0.000	-0.851	-1.207	-0.510	
LABOR FORCE											
OLD TECH	14527.7	1855.5	11.7	1095.8	0.0	1015.5	0.0	527.1	0.0	0.0	19033.4
NEW TECH	30948.3	3045.7	59.3	4552.8	4329.7	1043.5	2583.0	489.8	1264.5	2129.9	50446.6
TOTAL	45476.0	4901.3	71.0	5648.6	4329.7	2059.1	2583.0	1016.9	1264.5	2129.9	69479.9

TOTAL LABOR SUPPLY: 69480 EMPLOYED: 69480 PERCENT EMPLOYED: 100.0 DUAL VALUE: -0.485

FINAL DEMAND REPORT

	DELIVERING SECTORS											
	AF	AL	EP	PG	CG	TC	CO	HO	FD	GS	TOTAL	DUAL
INTERINDUSTRY DEMAND												
	38178.2	3479.5	14426.7	99656.7	19031.7	12272.0	0.0	0.0	0.0	0.0	187044.7	
CONSUMPTION												
PEASANTS	4790.6	10049.3	0.0	116.7	6858.2	361.8	0.0	2360.8	4340.4	0.0	28877.7	-4.350
WORKERS	4747.8	7152.2	0.0	399.8	14633.2	1722.8	0.0	5405.4	14302.0	0.0	49363.3	-4.450
OPTIONAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4118.0	0.0	4118.0	
TOTAL	9538.3	17201.5	0.0	516.5	21491.5	2084.6	0.0	8766.1	22760.3	0.0	82358.9	
INVESTMENT												
FIRST YEAR	0.0	852.9	0.0	9014.3	0.0	0.0	10089.8	0.0	0.0	0.0	19956.9	
2ND YEAR	0.0	0.0	0.0	38510.4	0.0	0.0	38713.5	0.0	0.0	0.0	77223.9	
TOTAL	0.0	852.9	0.0	47524.6	0.0	0.0	48803.3	0.0	0.0	0.0	97180.8	
STOCK GROWTH												
OLD TECH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
NEW TECH	862.9	0.0	0.0	2728.1	8447.0	0.0	7456.1	0.0	0.0	0.0	19494.1	
TOTAL	862.9	0.0	0.0	2728.1	8447.0	0.0	7456.1	0.0	0.0	0.0	19494.1	
GOVERNMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19726.4	19726.4	
FOREIGN TRADE												
EXPORTS	345.2	1122.4	0.0	3000.8	376.0	0.0	0.0	0.0	0.0	0.0	4844.4	
IMPORTS:												
OLD TECH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
NEW TECH	118.6	54.9	0.0	3530.1	410.7	0.0	0.0	0.0	0.0	0.0	4114.3	
OPTIONAL	0.0	0.0	0.0	0.0	730.1	0.0	0.0	0.0	0.0	0.0	730.1	
TOTAL	118.6	54.9	0.0	3530.1	1140.8	0.0	0.0	0.0	0.0	0.0	4844.4	
NET EXPORT	226.6	1067.5	0.0	-529.3	-764.8	0.0	0.0	0.0	0.0	0.0	0.0	-9.230
FOREIGN TRADE CREDITS										0.0		
FINAL DEMAND TOTALS												
	10627.8	19121.8	0.0	50240.3	29173.7	2084.5	56259.4	8766.1	22760.3	19726.4	218760.3	
GROSS VALUE OF OUTPUT												
OLD TECH	0.0	0.0	525.7	0.0	0.0	2761.6	0.0	2187.3	0.0	0.0	5575.5	
NEW TECH	48806.0	22601.4	13800.0	149896.9	48205.5	11595.0	56259.4	5578.9	22760.3	19726.4	400229.5	
TOTAL	48806.0	22601.4	14426.7	149896.9	48205.5	14356.6	56259.4	8766.1	22760.3	19726.4	405805.1	
DUAL VALUES OF DISTRIBUTION CONSTRAINTS												
	-8.518	-5.741	-2.333	-3.089	-9.230	-9.571	-3.172	-16.742	-2.413	-7.611		

ALPHA=BETA=555577. ALEPH=BETH=1155.95.95. FINAL K,B ADJUSTMENTS.
YEAR IS 1940

RESOURCE UTILIZATION REPORT

	PRODUCING SECTORS										
	AF	AL	EP	PG	CG	TC	CO	HO	TD	GS	TOTAL
CAPITAL STOCK											
OLD TECHNOLOGY											
STOCK	3022.0	3153.1	332.2	1592.6	1473.8	7610.9	188.1	14837.1	281.6	4137.5	36719.0
UTILIZED	0.0	0.0	332.2	0.0	0.0	7610.9	0.0	14837.1	0.0	0.0	22780.2
PERCENT	0.0	0.0	100.0	0.0	0.0	100.0	0.0	100.0	0.0	0.0	62.0
CAPACITY CONSTRAINT											
DUAL VALUE	0.000	0.000	-0.317	0.000	0.000	-0.419	0.000	-2.152	0.000	0.000	
NEW TECHNOLOGY											
STOCK	17938.3	11545.1	11255.1	65107.2	8785.3	35240.1	4766.4	28504.4	6185.0	21950.1	211337.8
AVAILABLE	15445.0	10512.2	10212.7	52893.5	8701.7	32595.2	4303.3	27129.3	5873.8	21842.2	
UTILIZED	15444.9	10512.3	10212.7	35151.3	8701.6	32595.2	4303.3	27129.3	5873.8	21842.3	171866.4
PERCENT	100.0	100.0	100.0	66.5	100.0	100.0	100.0	100.0	100.0	100.0	90.6
CAPACITY CONSTRAINT											
DUAL VALUE	-0.844	-0.508	-0.592	0.000	-1.181	-1.128	-1.970	-3.601	-3.991	-3.100	
TERMINAL INVESTMENT CONSTRAINT											
DUAL VALUE	-0.864	-1.153	-0.747	-0.751	-0.751	-0.752	-0.746	-0.754	-0.751	-0.758	
LABOR FORCE											
OLD TECH	0.0	0.0	10.5	0.0	0.0	944.2	0.0	486.8	0.0	0.0	1441.5
NEW TECH	46583.5	4457.3	80.3	6609.0	5396.8	1374.4	3333.1	701.3	1595.5	2425.4	72556.4
TOTAL	46583.5	4457.3	90.8	6609.0	5396.8	2318.5	3333.1	1188.1	1595.5	2425.4	73997.9

TOTAL LABOR SUPPLY: 73979 EMPLOYED: 73998 PERCENT EMPLOYED: 100.0 DUAL VALUE: -2.869

CAN'T FINDSOLUTION

The central message of this reference solution is that the Soviet economy in the 1929-1940 period contained a very substantial potential for output expansion, under problem-free conditions, without much need for belt-tightening. Given the base period situation, no model is needed to suggest such a conclusion, since the resources and growth possibilities were obviously at hand. What the model does make possible, however, to the extent that its assumptions and calibrations are accepted, are at least some crude quantitative estimates of the degree and kind of expansion that might have been possible in the absence of any of the negative developments that actually occurred.

In summary form, the expansion path is marked out in the data of Table IV-19 and Chart IV-1. The economy's gross output in period six (1939 plus 1940) could have been some 3.8 times as large as in the base period (twice 1928). Deducting interindustry deliveries, the GNP could have risen from an index of 100 to an index of 424. Within these aggregates, consumption would have increased some 2.7-fold while investment was rising from an index of 100 to an index of 824. The stock of fixed capital at the beginning of 1941 would have been five times larger than it was at the beginning of 1929. Deliveries to final demand from the two agricultural sectors would have risen quickly, according to this reference solution, from a two-year total of 15.0 billion rubles in the base

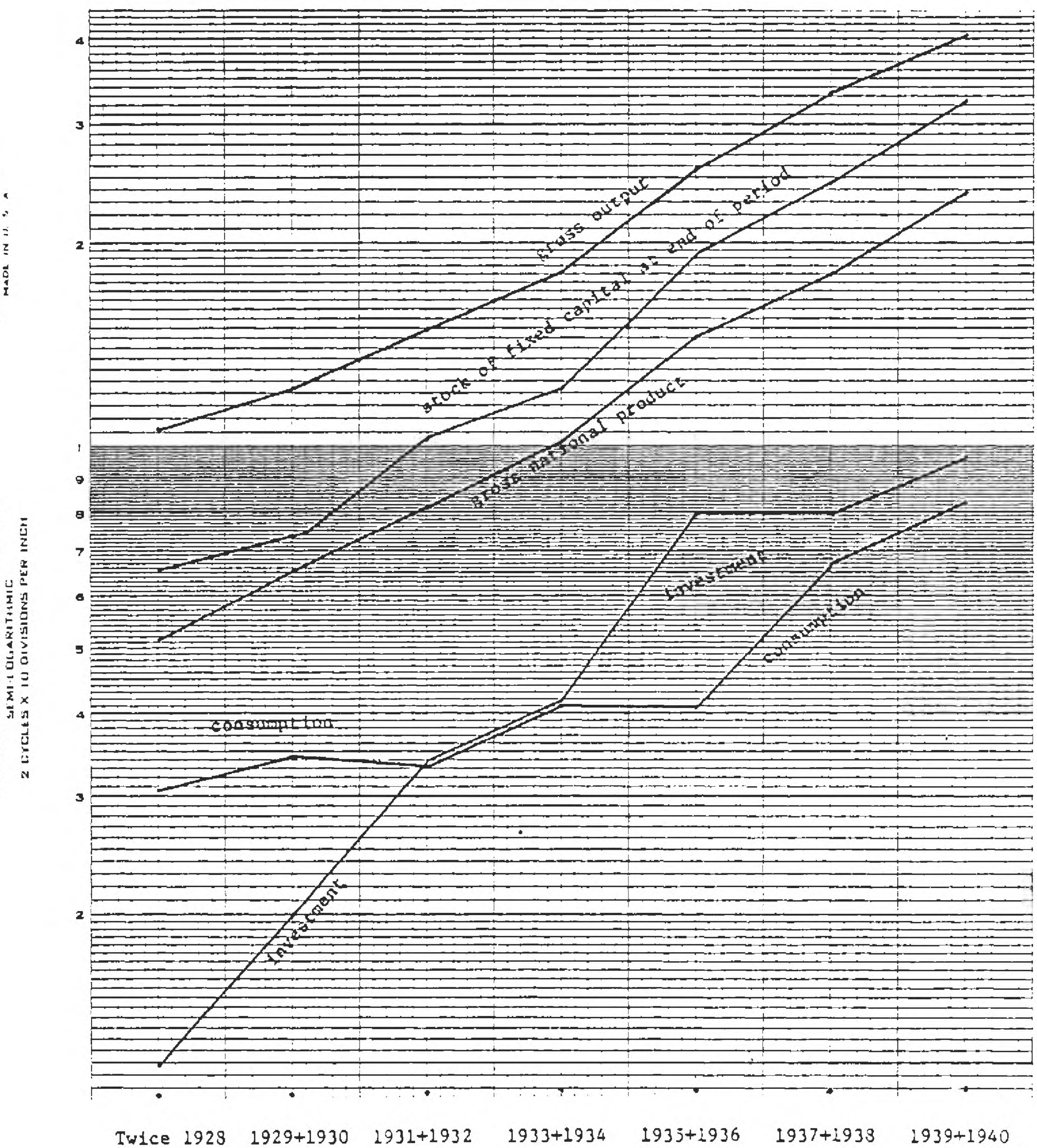
Table IV-19. Reference Solution Values for Gross Output, GNP, and Components, By Period,

absolute data in billions of rubles at base-period prices

	Twice 1928	1st Period	2nd Period	3rd Period	4th Period	5th Period	6th Period	6th Period Index(a)
Total gross output	106.0	122.2	149.3	182.1	258.1	331.8	405.8	383
GNP:								
Agricultural output	15.0	19.5	21.4	30.3	26.8	27.3	29.7	198
Industry and construction	16.9	26.4	39.6	51.2	89.1	107.4	135.7	803
Services	19.7	19.3	20.1	20.4	29.7	44.0	53.4	271
Total GNP	51.6	65.2	81.1	101.9	145.6	178.7	218.8	424
Consumption	30.6	34.4	33.2	41.0	40.6	66.7	82.4	269
Investment	11.8	20.0	33.7	41.8	79.5	79.4	97.2	824
Government services	5.9	7.7	10.1	12.5	14.9	17.3	19.7	334
Exports	1.2	1.7	2.3	3.0	3.6	4.2	4.8	400
End-of-period stock of fixed capital	65.7	74.6	102.5	122.1	192.5	248.1	327.4	498
Percent increases per period:								
Total gross output		15.3	22.2	22.0	41.7	28.6	22.3	
Agricultural output		30.0	9.7	41.6	-11.6	1.9	8.8	
Industry and construction		56.2	50.0	29.3	74.0	20.5	26.4	
Services		-2.0	4.1	1.5	45.6	48.1	21.4	
Total GNP		26.4	24.4	25.6	42.9	22.7	22.4	
Consumption		12.4	-3.5	23.5	-1.0	64.3	23.5	
Investment		69.5	68.5	24.0	90.2	-0.1	22.4	
Percent shares in GNP:								
Consumption	59.3	52.8	40.9	40.2	27.9	37.3	37.7	
Investment	22.9	30.7	41.6	41.0	54.6	44.4	44.4	
Absolute increments per period:								
Fixed capital		8.9	27.9	19.6	70.4	55.6	79.3	
GNP		13.6	15.9	20.8	43.7	33.1	40.1	
Incremental capital/output ratio		0.65	1.75	0.94	1.61	1.68	1.98	

(a) With the base period (twice 1928) taken as 100.

CHART IV-1. REFERENCE SOLUTION VALUES FOR GROSS OUTPUT AND RELATED SERIES, BY PERIOD, IN BILLIONS OF RUBLES AT BASE-PERIOD PRICES



period to a total of 30.3 billion in period three, then fallen off slightly to 27 billion in the next two periods and 30 billion in the sixth period -- double the initial level. Clearly so rapid a degree of improvement in agriculture is empirically rather unlikely. Over this same period the output of the service sectors would have been rising from an index of 100 to an index of 271, with the growth concentrated in the last three periods. Deliveries to final demand by the two industry sectors and the construction sector would have grown rapidly and continuously, reaching by the sixth period a level eight times higher than the base-period level. Thus would the optimistic hopes of the system's directors have been realised.

Expansion on this scale would have required a drastic shift away from consumption and toward investment. Though the absolute level of consumption would not have fallen, and in fact it would have risen from 30 to over 80 billion rubles, the share of consumption in GNP would have declined from 59% in the base period to a low of 28% in the fourth period and an apparently stable share of 37-38% in the last two periods. Conversely, the absolute amount of investment would have risen from 12 billion rubles to almost 100, and the investment share in GNP would have increased from 23% to 55% in period four and 44% thereafter. This stress on capital formation would of course have raised capital stocks very substantially, to more than three times their size at the beginning of 1929. Comparison of period-to-period increments in fixed capital and in GNP discloses erratic changes in the incremental capital/output ratio, which rises from 0.65 in the first period to 1.98 in the sixth. These are very low values, by comparison with recent LDC experience, especially in view of the sectors being stressed. Again it is evident that this reference solution embodies optimistic parameters.

Given our way of projecting out to 1940 the Gosplan intentions for

final-demand deliveries to exports and to government services during 1929-1933, their shares of GNP show modest changes. Exports made up 2.4% of Soviet GNP in 1928, and this share rises to 2.9% in periods two and three, only to fall off to 2.2% in the sixth period. Similarly, government services account for 11.4% of the 1928 GNP, a share that would have risen to 12.5% in period two and then declined to 9% by the sixth period.

Inspection of the dual valuations in this reference solution reveals a crucially binding constraint in the construction sector in the second period. It was here that limitations on the amount of fixed capital construction begun before the plan period but not yet completed, together with the limitation imposed by a two-period gestation period for new fixed capital, would have placed an insurmountable barrier to further advance. Once past this bottleneck in the second period, the model generates construction-sector output without strain and the dual values fall to negligible levels. There is also an indication that electric power in the second period was under considerable strain, but that the strain would have been relieved thereafter. The pattern of dual valuations varies noticeably under experimentation since these values are quite sensitive to the linear structure of the model. They are not to be relied on for a precisely detailed account of sectoral and temporal strains in this hypothetical reconstruction of a problem-free expansion path.

Through further juggling of weights on individual terms in the model's objective function (peasant consumption in each period, worker consumption in each period, and sectoral capital stocks in the final period), we could have smoothed out some of the sharp fluctuations evident in this reference solution, and tailored the capital pattern more closely to assumed Party intentions. The analytic gain would be negligible. Sharp shifts are inherent in linear programming. As long as one can assume convexity in the model's structure,

a linear combination of two neighboring solutions will be feasible by definition, so gradual transitions are implicitly available, even if not strictly optimal. This particular reference solution, for example, builds 161 billion rubles worth of new-technology capital in the producer goods sector by January 1, 1941, and only 10.1 billion billion rubles worth for the electric power sector. Examination of Table IV-18 above, recording Solution #9, shows however that by reversing the weights on capital stock for these two sectors we can reverse the proportions, creating 114 billion rubles worth of capital stock in electric power, and 53.4 billion in producer goods. In practice, the combined total of about 170 billion rubles could have been divided between these two sectors in almost any desired proportions, within the overall set of constraints forming the model. The linear programming model tells us about the zone which bounds feasible territory; it need not be interpreted as marking out a single, unique, fine-scale "optimal" solution.

It should also be noted that the feasibility of this problem-free reference solution is affected by its high degree of aggregation. A linear programming approach treats the activities within each sector as completely homogeneous so that intrasectoral flows are not constrained by technical coefficients, and intermediate goods are completely substitutable for each other. "It is not known in advance whether aggregation of sectors, on balance, overstates or understates the potential achievements of a system. Aggregation permits full substitution within sectors and thus may overstate production potential. On the other hand, if as the result of aggregation the average input requirements imposed in a particularly fast-growing part of the economy are higher than if that sector were treated separately, the effect is to penalize growth." More-

over our use of two-year time periods "...implies complete substitution within each period. This provides "an additional degree of freedom in breaking bottlenecks, which is not in fact present..." (though changing from one year to two years cannot have a decisive influence on evolution over a twelve-year horizon). "On the other hand there may be compensating disadvantages in time aggregation since it forces a kind of synchronization among sectors in each aggregated time period which in actuality need not be present." Quotes from R. S. Eckaus and K. S. Parikh, Planning for Growth (1968), p. 154.

In this chapter we have sought to obtain a multisectoral, multiperiod picture of the way the Soviet economy might have expanded from 1928 through 1940 if the economy's potential had been drawn on as the Party intended and no difficulties had intervened. Our reference solution appears to mark out the upper limits of the possible. In historical actuality, however, the economy suffered a number of serious blows, each leaving its mark on parts of the system. After sketching the key developments in the next chapter, we use the model in Chapter VI to decompose the actual record in order to measure the impact of these events, thus accounting for the differences between our reference solution and the actual course of events.

VI. DECOMPOSING THE RECORD TO MEASURE THE IMPACT OF MAJOR EVENTS

Having compiled broad evidence concerning several major economic developments in the USSR during the 1930s, we are now ready to insert these data into the quantitative framework provided by our reference solution for the 1928-1940 period. Each of the events had an obvious bearing on specific aspects of the economy. Taken all together, the developments ought to account for the observed differences between the actual path of the Soviet economy and the problem-free path spelled out in our reference solution. In theory it should be possible to derive quantitative estimates of the relative importance of the individual events in affecting overall results. Ideally, therefore, we might hope to decompose the actual record, identifying and measuring the major causal factors at work. This would not be counterfactual history, trying to estimate what did not happen, and thus should not offend those who, like Edward Hallet Carr, call for a focus on the interacting complexities of events as they in fact occurred.

For several reasons, caution is in order concerning the precision of results to be expected. Soviet statistics for the 1930s were collected under conditions that tended to produce exaggerations, and were reported in ways that distorted the record. Even if these defects in the evidence can be overcome, valuation issues during a period of marked structural transformation introduce ambiguities that make single-valued answers impossible. In addition, our ten-sector, six-period model is quite highly aggregated, and though its rigidities are reduced by a number of technical features, results generated by the model reflect its oversimplified design. Models with other properties would tell a different story using the same evidence. We have found, nevertheless, that extensive experimentation discloses some central tendencies that stand up under

a variety of alternative assumptions and over a wide range of parametric variations. The numerical pattern that emerges is, fortunately, fully in accord with the qualitative impressions that prevail among most students of the period. We assert, therefore, that our results provide useful illustrative detail that throws illuminating light on the forces at work in a very important and interesting period of structural change.

Of the seven developments in the Soviet economy described in Chapter V above, the investment drive has already been built into our reference solution, along with three of the four years of transport strain. The influence of two other developments: (a) inflation, rationing, and consumer goods shortages, and (b) political purges and mass terror, was indirect and not easily measured. We focus, therefore, on the effects of the world depression, of rearmament, and of agricultural collectivization, each of which can be easily translated into linear constraints suitable for inclusion in KAPROST. The first two were clearly exogenous influences; the Soviet government had no control over the world-wide depression, and little choice but to rearm. However the decision to collectivize, and its attendant effects, were solely the result of internal policy decisions. Hence we will examine the impact of each of the exogenous influences separately, and then combine them to evaluate the total impact of external affairs on the Soviet economy. We then look at collectivization by itself, as most scholars would agree this was the most critical of Stalin's policy decisions. Finally we combine all three impacts, hoping to see a model solution which tracks historical reality fairly well. The difference between this composite solution and the actual record we attribute to those influences we have not been able to quantify, and the limitations of our basic model data.

As noted in Chapter IV, even with the constraints imposed by the model, an essentially infinite variety of solutions exist. This implies that the results we present are unavoidably influenced by our judgment as to what would be

appropriate and reasonable. We have tried to guide our choices by those goals which were nearly universal among Soviet policy makers: economic development through capital investment, with consumption as a secondary objective.

The Trade Impact of World-Wide Depression

Soviet foreign trade statistics for the 1930s are even more complicated than those of other countries in normal times, as the economy was undergoing structural change, and price movements were very marked during the world depression. Many alternative weight years deserve consideration and index number issues abound. Straightforward, unambiguous computations are not possible. We take advantage of Michael R. Dohan's painstaking research, and use his aggregate indices as presented in Table V-4 above.

Table VI-1 repeats Dohan's estimated volume index for Soviet foreign trade, along with the officially compiled series. Both indexes are derived from series in foreign-trade rubles, since the USSR does not release data on exports and imports in domestic prices. The official series corrects for exchange-rate changes but otherwise reflects current prices. Professor Dohan's series meticulously applies price weights of 1927/28 to quantity data with fuller and more consistent coverage than previously employed. As discussed more fully in his basic report, the corrected series show a smaller drop in imports and exports after 1931 than displayed by the official series, since the latter reflect both reduced quantities and lower prices.

While it is literally true that the money value of commodity trade shrank in the 1930s for both price and volume reasons, the whole KAPROST project is cast in constant-price terms. Hence we use Dohan's volume indexes to reflect changes in physical imports and exports over the 1928-1940 period, measured at

TABLE VI-1. Volume indexes for Soviet exports and imports, by year, 1928-1940, 1929 = 100

	EXPORTS		IMPORTS	
YEAR	OFFICIAL	DOHAN	OFFICIAL	DOHAN
1928	85.7	77.5	107.4	101.1
1929	100.0	100.0	100.0	100.0
1930	112.2	149.5	120.2	123.1
1931	87.8	164.0	125.5	146.1
1932	62.3	128.2	80.0	107.0
1933	53.7	124.6	39.6	66.2
1934	45.3	117.9	26.4	59.7
1935	39.8	105.6	27.4	66.8
1936	33.6	83.7	35.1	68.0
1937	40.8	87.3	33.1	62.2
1938	31.7	78.0	35.5	69.2
1939	14.4	(40.2)*	24.3	(46.8)*
1940	33.1	(138.3)*	35.5	(68.4)*

Sources: Official index derived from absolute figures at the 1950 ruble exchange rate in MVT, Vneshniaia Torgovlia SSSR ZA 1918-1940 gg (1960), p.17. Dohan indexes from Michael Dohan and Edward Hewett, Two Studies in Soviet Terms of Trade, 1918-1970 (Bloomington, Indiana: Indiana Univ. Int. Development and Research Center, 1973), pp 24 and 27.

* Our estimate, as described in text.

constant prices. Our reference solution incorporates hypothetical export and imports obtained by extending planners' intentions in a problem-free environment; we want to replace these trade figures with quantity flows reflecting the physical changes that occurred. The additional impact of worsened terms of trade is analyzed by Michael Dohan; no attempt to enter this range of issues is made here.

The Dohan series ends in 1938, while our model requires data through 1940. The extension was accomplished by applying the proportionate changes in the official series for 1939 and 1940 to the last number in Dohan's series. These estimates are in parentheses in Table VI-1.

While in time it would be possible to derive disaggregated trade series compatible with KAPROST's four trading sectors, we have initially limited ourselves to applying aggregate indexes equally to trade in each sector. The model requires exogenous estimates of exports by sector. Table IV-2 presents these on a yearly basis for the four exporting sectors, obtained by applying the Dohan index in Table IV-1 to the 1928 trade numbers in Table III-5. These are summed in Table VI-3 to yield two-year exports compatible with KAPROST's structure.

Imports in KAPROST are derived first as a ratio of achieved output, and second, if a net export surplus still exists, as discretionary increments to critical sectors. We would like to limit total imports to those amounts given in Tables VI-2 and VI-3. As the model requires net exports plus foreign trade credits to balance in all periods, by setting foreign trade credits equal to net imports, this result is achieved. Table VI-3 presents all the data needed for the trade scenario.

Characteristics of the Trade Solution.

Application of the trade data with no further modifications has a crippling effect on the KAPROST solution. Capital stock falls to 25% of the reference solution, sixth period output to 30% of the reference. Examination

TABLE VI-2. Exports by Year and Sector, Total Imports

(Millions of Rubles)

YEAR	SECTOR / EXPORTS: AGRICULTURE, FIELD CROPS	AGRICULTURE, LIVESTOCK PRODUCTS	PRODUCER GOODS INDUSTRY	CONSUMER GOODS INDUSTRY	EXPORT TOTAL	IMPORT TOTAL
1928	76	230	263	50	619	792
1929	98	297	339	65	799	783
1930	147	444	507	96	1194	965
1931	161	487	557	106	1310	1144
1932	126	380	435	83	1024	838
1933	122	370	423	80	995	519
1934	116	350	400	76	941	468
1935	104	313	358	68	844	524
1936	82	248	284	54	669	533
1937	86	259	296	56	697	487
1938	76	231	265	50	623	542
1939	31	92	106	20	249	371
1940	105	318	364	69	856	542

1928 Values are from reconstructed input-output Table III-5.

Other values obtained by applying the Dohan index, Table V-1 to the 1928 values.

TABLE VI-3. Historical Trade Data for KAPROST.

(Millions of rubles)

SECTOR

EXPORTS

PERIOD	AGRICULTURE, FIELD CROPS	AGRICULTURE, LIVESTOCK PRODUCTS	PRODUCER GOODS INDUSTRY	CONSUMER GOODS INDUSTRY	EXPORT TOTAL	IMPORT TOTAL	FOREIGN TRADE CREDITS
1929-30	245	741	846	161	1993	1748	-245
1931-32	287	867	992	189	2334	1982	-352
1933-34	238	720	823	156	1936	987	-949
1935-36	186	561	642	122	1513	1057	-456
1937-38	162	490	561	106	1320	1029	-291
1939-40	136	410	470	89	1105	913	-192

Two year total from Table VI-2, except for:

Foreign Trade Credits = Import Total - Export Total.

of the detailed output showed clearly that, given the required import ratios, the historical level of imports will not support any greater level of economic activity. As this output is significantly below that which actually occurred during the 1930s, an adjustment is obviously necessary.

The USSR made some emergency imports of raw cotton, steel, copper, and a few consumer goods at the start of this period, and many of the early, one-time imports of machinery and equipment embodied advanced technology that played a key role in subsequent industrial expansion. But while world depression clearly reduced planners' flexibility, there is no evidence that any significant loss of output resulted from an inability to import goods after 1932. Some level of required imports should be retained to assure that imports are distributed among all importing sectors, but not so much as to significantly bind the system. To make this descriptive result precise, the required import ratios were lowered proportionately until: the largest dual valuation (shadow price) on the balance of payments constraint is of the same magnitude as the dual value of other constraints; and that each period shows some amount of optional imports, but in some period that number is relatively small.

Table VI-4 presents a comparison of the effect of imposing varying fractions of the original required import ratios (Appendix C, Table 14) on the reference solution. The trade data from Table VI-3 are used, but all other data and parameters are as in the reference solution described in Chapter IV. Note that as none of the objective function weights have been changed, the objective function value is comparable across solutions.

Examination of Table VI-4 indicates that we want to impose between 20 and 25% of the original required import ratio. Between these two values, the dual value of the most stringent balance of payments constraint rises sharply,

Table VI-4. Effects of Varying the Required Import Ratios
(Billions of Rubles)

Percent of Required Import Ratio	(1) Total Capital Stock	(2) 6th Period Total Output	(3) Largest Dual Value	(4) Least Optional Imports	(5) Value of Objective Function
100%	77.8	129.3	219	0.0	807.2
75%	118.0	169.9	211	0.0	934.5
50%	186.8	246.9	210	0.0	1040.9
25%	279.7	377.0	196	0.0	1133.2
20%	290.8	407.0	10	.085	1207.4
10%	292.7	408.4	10	.497	1211.6
0%	294.7	409.9	10	.913	1215.8
Reference Solution	294.0	405.8	9	.236	1219.4

(1) New technology capital stock, January 1, 1941.

(2) Total 1939 + 1940 output.

(3) Highest dual valuation on balance of payments constraint over all six periods. Objective-function increase per unit rise in constraint.

(4) Smallest total of optional imports over all six periods.

(5) Calculated value of the objective function, summing consumption over six periods and Jan. 1, 1941 capital stocks over ten sectors.

and we begin to see a sharp deterioration in capital stock and output. Note that with no required imports, or only 10% of the original ratio in force, the trade scenario is comparable to the reference solution. Hence it is only by diminishing the flexibility allowed to the optimizing algorithm (or Soviet planners) that world depression has an important impact on the USSR.

The summary report for the "20% solution" is reproduced in Table VI-5, and for the "25% solution" in Table VI-6.

The Effects of Rearmament.

Rearmament was felt in the Soviet economy only during the last half of the 1930s. In evident recognition of the fact that military hardware cannot be produced without a sizable heavy industry sector, the initial investment surge focused on producer goods industry. However, military hardware requires military manpower, and, then as now, the exact division of military expenditures among branches of industry is difficult to ascertain. Hence we are forced to estimate some components of military demand from manpower levels, assigning the remainder to hardware.

Table V-6 above presents the Defense expenditures and Armed Forces manpower levels for the Soviet Union over our simulation horizon. Note that for the years 1928-1932 both figures are nearly constant (or unavailable). As a result we decided to take this minimum force level, 560,000 men and their associated costs, as implicit in the economy. Thus we assume no changes due to defense in 1929-1932, the first two simulation periods, and we subtract expenditure and manpower requirements for these men from all later years before calculating the impact of rearmament.

Where, then, is defense spending to be applied to the economy? We assumed it would occur in basically two ways. First, troops need food, clothing, shelter and other basic equipment, both for themselves and their dependents,

Table VI-5. Trade Scenario -- 20% of Required-Import Ratio in Force

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 1207623.0

ELEMENTS OF THE OBJECTIVE FUNCTION

	SECTORS										
	AF	AL	EP	PG	CS	FC	GO	HO	TD	SS	TOTAL
CAPITAL-42	15401.9	9638.8	10219.1	155973.4	8214.7	33174.7	3973.1	25715.4	5604.1	20532.1	290771.3

	YEAR							
	29830	31832	33834	35836	37838	39840	41842	43844
PEAS CONS	24481.6	19925.4	24980.2	17158.5	27549.5	30303.5		
WORK CONS	10223.7	13499.1	15537.3	23468.3	30016.4	52310.4		

OTHER SUMMARY DATA BY YEAR

	29830	31832	33834	35836	37838	39840	41842	43844
OUTPUT								
OLD TECH	107457.5	99389.5	79575.1	64207.3	39950.4	5575.5		
NEW TECH	13359.3	49192.6	111375.4	193137.7	289556.6	401413.3		
TOTAL	120816.8	148582.0	181951.5	257345.0	329507.0	406988.8		
CAPITAL STOCK								
OLD TECH	59998.0	54206.1	49058.5	44473.4	40390.4	36719.0	33436.9	
NEW TECH	5751.0	20422.1	53362.9	77340.7	151019.9	208160.8	290771.3	
TOTAL	65749.0	74628.2	102421.4	121814.0	191410.3	244879.8	324208.1	
NEW CAPITAL		15260.0	35024.9	20057.0	90819.1	70255.7	101742.8	32275.3
LABOR FORCE								
SUPPLY	55350.0	59527.0	62857.0	65034.0	59480.0	73998.0		
EMPLOYED	50648.1	52369.5	62454.7	66033.9	59479.8	73997.8		
IDLE	4701.9	7157.5	414.3	0.1	0.2	0.2		
PER CENT	8.5	12.0	0.7	0.0	0.0	0.0		

Table VI-6. Trade Scenario -- 25% of Required-Import Ratio in Force

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 1183254.0

ELEMENTS OF THE OBJECTIVE FUNCTION

	SECTORS										
	AF	AL	EP	PG	CG	TC	CO	HO	TO	GS	TOTAL
CAPITAL-42	15242.9	24713.2	8943.4	142283.2	7782.4	27793.4	3137.1	24131.5	5213.7	20431.1	279733.8

	YEAR							
	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
PLAS CONS	24459.0	19753.4	24695.3	17160.9	27741.5	31508.4		
WORK CONS	10238.1	13320.3	15527.1	23425.5	38249.5	47464.9		

OTHER SUMMARY DATA BY YEAR

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
OUTPUT								
OLD TECH	107507.0	99464.9	70634.6	64207.3	37944.9	5802.7		
NEW TECH	13359.3	49172.5	111303.5	193478.3	288762.3	371165.4		
TOTAL	120466.3	148637.4	181938.1	257685.6	326707.1	376968.1		
CAPITAL STOCK								
OLD TECH	49998.0	54206.1	49058.5	44473.4	40380.4	36719.0	33436.9	
NEW TECH	5751.0	20422.1	53334.2	77863.5	150800.5	210803.8	279733.8	
TOTAL	55749.0	74628.2	102396.6	122336.8	191180.8	247522.8	313170.7	
NEW CAPITAL		15250.0	35000.2	29563.7	80152.8	73407.6	87968.6	80480.3
LABOR FORCE								
SUPPLY	55250.0	59527.0	62859.0	65004.0	69480.0	73998.0		
EMPLOYED	50653.1	52390.0	62858.9	65003.9	69479.8	73997.8		
IDLE	4596.9	7137.0	0.1	0.1	0.2	0.2		
PER CENT	8.3	12.0	0.0	0.0	0.0	0.0		

which implies consumption demand and some capital investment not very different from that of other sectors of the economy. Second, especially in the late 1930s, an army required deliveries of trucks, tanks, artillery, planes, ships, etc., all of which come directly from the Producer Goods sector.

In order to provide for the soldiers, we simply employed them through the Government Services sector of the economy. As shown in Table VI-7, we take average armed forces manpower in model periods 3 through 6, subtract 560 thousand to determine the increase above minimum force levels and then, using the output-labor ratio for new technology in the Government Services sector, determine the increase in demand for such output needed to employ those men. We add this to historical levels of Government Services output to obtain the new value of government demand for Government Services in KAPROST. Note this will not only employ labor equal to the growth in the armed forces, but will also require the model to build more capital stock for that sector (government office buildings and army barracks are presumed more or less equal). The wages paid to the workers will generate increased demand for consumption (soldiers and workers presumed more or less equal). Note that while army and civilian wages were certainly not equal, it is real demand for goods we are trying to generate by this scheme.

The demand for military hardware will be represented by a government demand for deliveries from the Producer Goods sector. The magnitude will be the total defense spending less that amount accounted for through increased government demand for output of Government Services and consumption demand by the soldiers so employed, as described above. These calculations are shown in Table VI-8. Note the increased consumption demand by soldiers is obtained by adjusting the wage payments by the average consumption coefficient, .5 in periods 3 and 4, .7 in periods 5 and 6.

TABLE VI-7. Increased Demand for Government Services Due to Increased Size of Armed Forces

PERIOD	(1) ARMED FORCES SIZE	(2) ARMED FORCES INCREMENT	GOVERNMENT SERVICES OUTPUT (3) INCREMENT	(4) HISTORIC	(5) TOTAL
3	913	353	2871	9867	12738
4	1184	524	5075	11119	16194
5	1473	913	7425	12664	20089
6	3534	2974	24188	14823	39011

(1) Two year averages from Table V-6, in thousands

(2) = (1) - 560. 560 is the average 1929-1932 force level, in thousands.

(3) = (2) x 8.13315, thousands of rubles. 8.13315 is the output-labor ratio for Government Services new technology production.

(4) Two year total from Table V-9, the row for Government Services sector, in thousands of rubles.

(5) = (3) + (4), in thousands of rubles.

One further adjustment is required. For the first two periods we reduce government demand for Government Services to historical levels. In keeping with the capital stock and capital productivity adjustments described in Chapter IV we adjust both old and new technology output-capital ratios in this sector to achieve exactly the historical output in periods 1 and 2 (Table VI-9). In the reference solution we had used linearly interpolated values from 1928 actual and 1933 planned levels.

Developing a Solution with Rearmament.

As with the trade scenario, direct application of the rearmament data to the reference solution does not have a salubrious effect; in fact, an infeasible solution results. All of the competing demands on output cannot be satisfied simultaneously, so we proceeded in good Soviet fashion to lower consumer demand. By lowering real wages to 50% of nominal wages, and reducing the fraction of consumer demand satisfied in fixed proportions for the last two periods to half, the model solved. This type of improvement is what one would expect in a real economy: guns are possible when the amount and variety of butter is reduced.

The solution still showed some undesirable characteristics: consumption was too low in some periods, and in others included too much of one sector's output but not enough of others; capital stock was low, and could have been distributed better; etc. Further adjustments were made to the real wage and consumption proportion parameters, and to the objective function weights for capital in agriculture (livestock) and producer goods, as well as third period peasant consumption. Table VI-10 lists the differences in parameter settings for this solution versus the reference. Table VI-11 presents our "rearmament only" solution.

TABLE VI-8

Demand for Military Hardware

Period	(1) Total Defense Spending	(2) Government Services	(3) Military Consumption Demand	(4) Military Hardware
3	6440	2871	539	3030
4	23069	5075	991	16995
5	40632	7425	2180	31027
6	95933	24188	6807	64983

All values in thousands of rubles.

(1) Two-year totals from Table V-6

(2) From Table VI-7, Column 3.

(3) Table VI-7, Column 1, multiplied by the Government Services wage rate for each period (Appendix C, Table 10, minus 907.3 thousand rubles (the basic wage cost for 560 thousand soldiers in 1929) all multiplied by the average propensity to consume, .5 in periods 3 and 4, .7 in periods 5 and 6.

(4) = (1) - (2) - (3), the government demand for deliveries from the Producers Goods sector.

Table VI-9

Adjustments to Government Services
Output-Capital Ratios, Periods 1 and 2

(1)	GS Output 1929-1930	6786
(2)	New Technology	222
(3)	Old Technology	6564
(4)	GS Old Technology Capital 1929-1930	5519
(5)	Adjusted Old Technology Output-Capital Ratio for Periods 1 and 2	1.18935
(6)	GS Output 1930-1931	9279
(7)	Old Technology	6196
(8)	New Technology	3083
(9)	GS Available New Technology Capital 1929-1930	1079
(10)	Adjusted New Technology Output-Capital Ratio for 1930-1931	2.85728

All values in thousands of rubles except lines (5) and (10).

(1) Two-year total, Table V-9

(2) First period new technology capital stock (246) from Appendix C, Table 6, multiplied by first period new technology output-capital ratio (0.90313)

(3) = (1) - (2)

(4) From Appendix C, Table 6

(5) = (3) ÷ (4)

(6) Two-year total, Table V-9

(7) = (3) depreciated one period

(8) = (6) - (7)

(9) From Table IV - 5

(10) = (8) ÷ (9).

Table VI-10

Control Parameter Settings: Rearmament vs. Reference

Parameter	Rearmament	Reference
Objective Function Weights		
Capital Stock, 1/1/41		
Agriculture: Livestock	2.8	3.0
Producer Goods	3.2	3.1
Consumption		
1933-34	3.4	3.2
Average Propensity to Consume		
1929-30	0.4	0.5
1931-32	0.4	0.5
1933-34	0.4	0.5
1935-36	0.4	0.5
1937-38	0.4	0.7
1939-40	0.4	0.7
Fraction of Consumption in Fixed Proportions		
1933-34	0.3	0.5
1935-36	0.4	0.5
1937-38	0.8	0.95
1939-40	0.9	0.95

Reference solution parameter values from Table IV-8.

Parameters not listed are identical for both solutions.

Table VI-11. Solution Showing Impact of Rearmament (Millions of Rubles)

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 920190.9

ELEMENTS OF THE OBJECTIVE FUNCTION

	SECTORS										
	AF	AL	EP	PS	CS	TC	CD	HD	TD	GS	TOTAL
CAPITAL-42	14941.9	44273.8	13738.7	51877.1	8576.8	38738.3	2701.7	13102.5	3027.5	41927.4	242926.0

	YEAR							
	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
PLEAS CONS	28062.2	25549.7	16085.4	12351.5	13549.4	16708.0		
WORK CONS	8147.2	10639.7	11373.7	19412.2	24772.5	31665.5		

OTHER SUMMARY DATA BY YEAR

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
OUTPUT								
OLD TECH	107225.8	99278.3	66138.4	64207.3	52498.6	12210.4		
NEW TECH	13359.3	50848.2	100644.8	187796.4	287501.3	406790.1		
TOTAL	120585.0	149125.9	166783.3	252003.8	339999.8	419000.5		
CAPITAL STOCK								
OLD TECH	59998.0	54206.1	49058.5	44473.4	40380.4	36719.0	33436.9	
NEW TECH	5751.0	20422.1	47118.8	82516.1	134094.4	213959.9	242926.0	
TOTAL	65749.0	74628.2	96177.3	126989.4	174474.8	250678.9	276362.9	
NEW CAPITAL		15260.0	28780.8	39541.4	58980.7	91518.5	47671.5	71121.3
LABOR FORCE								
SUPPLY	55350.0	59527.0	52859.0	65004.0	59480.0	73998.0		
EMPLOYED	50549.9	52145.4	40309.9	60928.5	54602.8	73997.8		
IDLE	4800.1	7331.5	14559.1	5075.5	4877.2	0.3		
PER CENT	8.7	12.4	23.2	7.7	7.0	0.0		

Superficially, the impact of rearmament on the Soviet economy seems severe. Comparing Table VI-11 to the reference solution in Chapter IV, final capital falls from 327 to 276 billion rubles, and unemployment and consumption worsen in the final four periods. Despite a fair amount of effort, we were not able to avoid the unemployment and consumption impact, especially the severe third period result: 1933-34 unemployment of 23.2% versus 0% in the reference; 1933-34 total consumption of 27.3 billion rubles versus 41.0 billion rubles (twice the 1928 level of consumption is 30.5 billion rubles). The capital stock, however does not include 109 billion rubles of military hardware produced for defense (see Table VI-12 for the calculation of this figure). Further total output in the sixth period (1939-40) is approximately equal for both solutions: 405 billion rubles in the reference, 419 billion rubles with rearmament. KAPROST seems to indicate that while rearmament had a mild cost in terms of real income, it did not significantly halt development over the 1930s. Clearly, if war had not intervened, progress in the 1940s would have slowed by the reduced availability of productive capital, but the economic problems of the 1930s cannot be blamed on the preparations for war.

Table VI-12

Stock of Military Hardware, Jan. 1, 1941

Period	(1) Military Hardware Expenditures	(2) Depreciation Factor to 1/1/41	(3) Military Hardware 1/1/41
1933-34	3030	.72723	2203
1935-36	16995	.80869	13744
1937-38	31027	.89927	27902
1939-40	64983	1.0	64983
Total Military Hardware, Jan. 1, 1941:			108832

(1) From Table VI-8, Column 4. millions of rubles.

(2) Appropriate power of (1-Depreciation Rate) for old technology capital in the Producer-Goods sector.

(3) = (1) x (2).

The Combined Impact of Trade and Defense

Of the three events whose impact we can quantify and introduce into KAPROST, the deterioration of trade and the decision to rearm were driven by exogenous factors. Hence it is of some interest to determine how much these developments caused the Soviet economy to deviate from a more desirable path. Table VI-13 combines the preceding adjustments in order to do just this. All data modifications to implement the deterioration of trade (with 20% of the required import ratios in force), and all defense expenditures have been included. The consumption parameters and objective function weights are set as in the rearmament solution just discussed.

In examining this solution four things ought to be noted. First, both consumption and unemployment are maintained at reasonable levels - not as desirable as the reference solution, to be sure, but not conspicuously poor either. Second, while capital stock on Jan. 1, 1941 is significantly lower than that achieved in the reference, this fall is illusory. As noted above, the total does not include the military hardware produced. Third, sixth period (1939-40) total output, at 401.6 billion rubles, is insignificantly less than that achieved in the reference solution. Fourth, combined with the demands of the military, the balance of payments constraint becomes sharply binding in the sixth period, with a dual valuation of 284 to 1.

Collectivization in Agriculture

The effect of collectivization on agricultural output and capital stock is modelled very directly in KAPROST. Actual historical levels of both production and capital in agriculture are imposed as constraints on the model. We turn first to estimating these values, then to adapting them to the model, searching for a representative solution, and discussing the results.

Table VI-13. Combined Trade and Defense Scenario (Millions of Rubles)

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 891017.1

ELEMENTS OF THE OBJECTIVE FUNCTION

	SECTORS AF	AL	EP	PG	CG	TC	CO	MO	TO	GS	TOTAL
CAPITAL-42	15132.0	54158.5	13093.0	42242.0	8358.3	35075.8	2470.8	12300.0	3063.3	27.4	228850.0

	YEAR 29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
PEAS CONS	29226.1	25314.2	20805.1	12042.7	13745.1	17141.0		
WRKS CONS	7870.7	10240.5	11478.3	18149.8	24037.7	29012.0		

OTHER SUMMARY DATA BY YEAR

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
OUTPUT								
OLD TECH	105895.1	95429.1	57055.4	54207.3	52498.5	11807.5		
NEW TECH	13359.3	51741.0	103670.0	185295.8	278265.8	389755.2		
TOTAL	119254.4	148171.1	170725.4	249503.1	330764.3	401562.7		
CAPITAL STOCK								
OLD TECH	59998.0	54206.1	49058.5	44473.4	40380.4	35710.0	33435.9	
NEW TECH	5751.0	20422.1	48933.5	81075.1	130726.8	207977.8	228850.0	
TOTAL	65749.0	74628.2	97994.1	125548.4	171107.1	244595.4	262287.8	
NEW CAPITAL		15250.0	30601.5	35579.6	55910.8	48557.3	30221.7	58045.0
LABOR FORCE								
SUPPLY	55350.0	59527.0	62850.0	56004.0	69480.0	73998.0		
EMPLOYED	50184.6	51741.0	53941.0	52750.2	64331.3	73997.8		
IDLE	5165.4	7785.1	8927.1	3253.8	5148.7	0.2		
PER CENT	9.3	13.1	14.2	5.8	7.4	0.0		

We have already described briefly the way that collectivization of agriculture led to smaller herds of livestock and reduced availability of animal draft power and livestock products, while at the same time raising the share of agricultural output that was taken for off-farm use. The Soviet diet, both urban and rural, deteriorated substantially. Detailed analysis is beyond the scope of this study, but a few computations will illustrate some of the changes and also supply data so that KAPROST can reflect their impacts.

The shrinkage of livestock herds was a very unfavorable development but it had the incidental effect of releasing for human consumption some of the grain and other feed that had been supporting livestock. Without attempting to trace consumption of vegetables, oilseed cake, etc., one can make crude estimates of the shift in grain consumption on the basis of readily available data. Before collectivization about half the total grain crop was consumed directly as food while roughly a quarter of it went into feed for animals. The big consumers were horses, especially those of working age, and hogs; smaller amounts went to cattle, sheep and goats, and poultry. Using summary official data for herd numbers together with feeding rates per animal as carefully evaluated by Naum Jasny, Table VI-14 indicates the magnitude of the changes in grain use by working horses, hogs, and cows (omitting young horses, beef cattle, sheep and goats, and poultry). The first three columns show the size of the absolute number, in millions of head, by which the January 1 animal count fell short of the number on hand at the beginning of 1929, year by year through 1940. For example, the 22.4 million working horses available in 1929 were reduced by January 1, 1935, to 10.4 million, a decline of 12.4 million. After 1934 the horse population rose again, reducing the shortfall. There was restoration in the number of cows, too, and the number of hogs rose above the base-period level.

Applying feeding rates of 450, 245, and 60 kilograms per animal per year, column 4 shows the amount of grain, in millions of tons, that was released by these declines in livestock herds. In a period when direct human grain consumption was in the neighborhood of 35 to 40 million tons per year, something like a fifth of it was made available this way. As Jerzy Karcz pointed out, "...the entire increase in grain marketings between 1928 and 1933 can be ascribed to the decline in livestock herds over that period. (The Economics of Communist Agriculture, Bloomington, Indiana; International Development Institute, 1980, p. 455).

Since labor was not a constraining input in agriculture, we can focus on changes in fixed capital as a key factor associated with the output changes reported in chapter V. Fixed capital in agriculture takes many forms: land, livestock, barns and houses, wagons, plows, and other equipment, etc., and in this project it has been subdivided between fieldcrop agriculture and livestock-products agriculture in fairly summary fashion. It is important to note that in Soviet agriculture at the beginning of the 1928-1940 period, draft power for conducting all agricultural activity, in both divisions of agriculture, was overwhelmingly animal power -- horses together with oxen in the South and a few camels in Soviet Central Asia. We have therefore assigned the value of the 32.6 million horses on hand at the beginning of 1929 -- making up about 49% of the total value of all livestock -- to fieldcrop agriculture, leaving the cattle and cows, hogs, sheep and goats, poultry, and bees to be part of the fixed capital in the livestock-products division of the agricultural sector. Both stocks declined and rose again, as shown in Table VI-14. The loss of animal draft power was a major blow to agricultural operations, forcing the Party to provide first imported and then domestically-produced tractors to fill the gap. In addition a substantial volume of mechanized equipment in the form of reapers, harvesters,

Table VI-14

Reduced numbers of working horses, hogs, and cows, and amount of grain released, by year 1929-1940, in millions of animals and metric tons.

	Working horses	Hogs	Cows	Grain Released
On hand, 1 Jan 29	22.8	19.4	29.2	
Decrement To Jan. 1				
1930	1.1	5.2	0.7	1.8
31	3.9	7.7	4.7	4.0
32	7.6	8.5	6.9	5.9
1933	10.7	9.5	9.8	7.7
34	12.0	7.9	10.2	7.9
35	12.4	2.3	10.2	6.8
36	12.0	-6.5	9.2	4.4
1937	11.7	-0.6	8.3	5.7
38	11.5	-6.3	6.5	4.1
39	10.8	-5.8	5.2	3.8
40	10.4	-3.1	6.4	4.4
1941	8.1	-8.1	1.4	1.7

Sources: Derived from herd data in TsSU, Selskoe Khoziaistvo SSSR (1960), p. 263, and feeding rates from Naum Jasny, "Soviet Grain Crops and Their Distribution," International Affairs, Oct. 1952, p. 458. The ratio of working to total horses was .732, .722, and .716 during 1927-29 (KTs 29/30, pp. 530-31). FYP, II, 1, pp. 332-33 puts it at .696 for 1927/28 and .692 for 1932/33 (intended). The TsSU series for all horses is here multiplied by .7. See also Jasny, Socialized Agriculture of the USSR, pp. 748-56, esp. p 751.

steel plows, etc., was delivered to agriculture, along with a modest number of trucks.

It has not been possible in this study to compile detailed estimates of this capital, but a series for the value of tractors is presented in Table VI-15, column 2. It will be seen that by 1934 the value of tractors on hand, in base-period prices, had grown to exceed the value of the remaining horses. According to Jasny's more comprehensive effort to assemble estimates for the sum of all animal and mechanical power available in Soviet agriculture (displayed in the graph above in chapter V, page V-6), the 1928 level of total draft power was not regained until 1938. Though the timing of the changes is uncertain, it is nevertheless clear that reduced draft power caused serious difficulties over this period. As for other fixed assets, we have taken refuge in the crude assumption that stocks remained constant from 1928 through 1940, i.e., that neither destruction nor construction caused major changes in what was available. We also make no effort to estimate the value of land as an input, following established Soviet practice. A more detailed analysis of agriculture might well distinguish a third subdivision for so-called technical crops (cotton, sugar beets, oilseeds, etc.), but this too is put aside for another investigation. We are left, then, with the two total asset series as devices for insertion into our baseline solution to model the impact of collectivization.

Modifications to KAPROST for the Collectivization Scenario

Imposing on the model the actual levels of capital stock and output in the two agricultural sectors will also fix investment in, and inter-industry deliveries to, these sectors - exactly what we require. There are several ways to incorporate these changes in KAPROST. Our choice was to add a new constraint placing an upper limit on new technology capital stock, and then adjust capital

Table VI-15

Actual fixed assets in fieldcrop and livestock-products agriculture, USSR, by year, 1928-1940, in billions of rubles at base-priced prices.

	Fieldcrops Agriculture				Livestock-products Agriculture		
Jan. 1	Horses	Tractors	Other	Total	Herds	Other	Total
1929	3.8	0.1	6.2	10.1	4.0	3.7	7.7
30	3.6	0.1	6.2	9.9	3.1	3.7	6.8
31	3.1	0.3	6.2	9.6	2.1	3.7	5.8
32	2.5	0.9	6.2	9.6	1.5	3.7	5.2
1933	2.0	1.7	6.2	9.9	1.3	3.7	5.0
34	1.8	2.8	6.2	10.8	1.5	3.7	5.2
35	1.7	4.4	6.2	12.3	2.0	3.7	5.7
36	1.8	6.3	6.2	14.3	2.9	3.7	6.6
1937	1.8	7.9	6.2	15.9	3.0	3.7	6.7
38	1.9	7.2	6.2	15.3	3.3	3.7	7.0
39	2.0	6.7	6.2	14.9	3.6	3.7	7.3
40	2.1(a)	6.0	6.2	14.3	3.7(a)	3.7	7.4
1941	2.1(a)	5.0	6.2	13.3	4.2(a)	3.7	7.9

(a) Including livestock on acquired territory.

Sources: The horse and non-horse livestock data are derived from estimates in Moorsteen and Powell, The Soviet Capital Stock, 1928-1962, pp. 105, 107, and 337. The tractor series is obtained by applying an assumed 5-year life to tractor production figures for 1926-1940 in TsSU, Promyshlennost SSSR, 1964, p. 279, and linking the resulting stock series to a ruble value at the end of 1928 of 54 million rubles, in KTs 29/30, p. 446. Other assets are valued in 1929 as explained in Appendix A, and assumed unchanged thereafter.

productivity so that if all possible capital stock is built and utilized, just the historically observed output levels result. Note that this provides the optimizing algorithm with the option of not building or not using some portion of agricultural capital stock in any of the periods -- with resulting loss in output as final capital. In practice, however, agriculture is a binding constraint on the solution and all capital allowed is built.

First we estimate the levels of capital stocks. As old technology capital stock simply depreciates, and is never increased, its values can be calculated for each period. New technology capital stock which is carried over from each period (or which is already established) can be calculated recursively by depreciating the previous years total new technology capital. The sum of these two items, when subtracted from total capital, yield each period's additions to new technology capital. Total new technology capital is the sum of the established portion and additions, while the available new technology capital counts only .7 of the additions in each period. These calculations are presented in Table VI-16 for field crops and Table VI-17 for livestock. Note that the reduction in herds is so great that it, strictly speaking, requires negative increments to capital stock in the second and third periods. As the MPS solution algorithm will not permit this type of outcome, we specify values which lead to zero additions to capital by lowering old technology capital in those two periods. This tends to underestimate the negative impact of collectivization, as no investment is obviously less costly than positive investment followed by destruction.

Given capital estimates, we adjust productivity in field crops by assuming old technology capital productivity is constant, and altering new technology productivity so that the available new technology capital will produce the remainder. (See Table VI-18). For livestock, even after reducing

Table VI-16

Capital Stock - Agriculture, Field Crops

Period	(1) K^O	(2) Established K^N	(3) Total K	(4) Z^N	(5) K^N	(6) Available K^N
1	7509	2591	10100	-	2591	2591
2	6259.3	2215.5	9600	1125.2	3340.7	3003.1
3	5217.5	2856.5	9900	1826	4682.5	4134.7
4	4349.2	4003.9	12300	3946.9	7950.8	6766.7
5	3625.4	6798.5	15900	5476.1	12274.6	10631.8
6	3153.1	10495.6	14900	1251.3	11746.9	11371.5

In millions of rubles.

(1) Old technology capital stock, depreciated from 1928 value

(2) New technology capital before including additions to capital for that period; depreciated value from previous period, column 5.

(3) Total capital stock, from Table VI-15, column 4.

(4) Additions to capital each period, = (3) -((1) + (2)).

(5) Total new technology capital stock = (2) + (4)

(6) New technology capital stock available = (2) + .7 x (4).

Table VI-17

Capital Stock - Agriculture, Livestock

Period	(1) K^O	(2) Established K^N	(3) Total K	(4) Z^N	(5) K^N	(6) Available K^N
1	7011	689	7700	-	689	689
2*	5212.3 (5975.5)	587.7	5800	-	587.7	587.7
3*	4498.6 (5092.9)	501.4	5000	-	501.4	501.4
4	4340.7	427.7	5700	931.6	1359.3	1079.8
5	3699.6	1159.5	6700	1840.9	3000.4	2448.1
6	3022	2559.5	7300	1718.5	4278	3762.5

In millions of rubles

(1) Old technology capital stock depreciated from 1928 value, except see * below.

(2) New technology capital before including additions to capital for that period; depreciated from the previous period, column 5.

(3) Total capital stock from Table VI-15, column 7.

(4) Additions to capital each period, = (3) -((1) + (2))).

(5) Total new technology capital = (2) + (4)

(6) New technology capital stock available for production = (2) + .7 x (4)

* Value used differs from value obtained by depreciation (in parentheses) for reasons explained in text.

capital stock levels and forcing no additions for two periods, old technology capital at original productivity levels produces more than the observed output. As a result, we summed old and available new technology capital, and divided this total capital into total output to obtain a common productivity ratio (Table VI-19).

The Collectivization Solution

Adjusting the reference solution after applying these modifications consisted of trying to raise consumption and lower unemployment as much as possible within the new framework. The average propensity to consume was lowered to .4 in all periods. The fraction of consumption required to be in fixed proportions is raised in the fourth period to attain reasonable values of optional consumption -- too large a contribution from trade and distribution arises otherwise -- and lowered slightly in the last two periods to allow more employment. These parameter changes are presented in Table VI-20.

The resulting solution appears in Table VI-21. Compared to the reference solution, final capital stock actually increases to 358 billion rubles from 327 billion rubles. This is a reaction to the inability of the optimizing algorithm to invest in agriculture or to produce output from sectors dependent on inputs from agriculture, i.e., consumer goods. Producer-goods industry benefits. Of course consumers pay the bill: consumption is down significantly in all periods after the first; unemployment is up in all periods, and exceeds 25% in the last four periods. It should be noted that this is not unemployment in the Western sense, but indicates the presence of supernumerary laborers and a decline in labor productivity throughout the economy. Finally, note that sixth period output is down to 320 billion rubles from 406 in the reference solution, an indication that the lagging agricultural sectors are undermining the whole economy.

Table VI-18

Productivity - Agriculture, Field Crops

Period	(1) X^O	(2) Total X	(3) X^N	(4) Available K^N	(5) 6^N
1	18341.9	22752	4410.1	2591	1.70209
2	15289.2	23599	8309.8	3003.1	2.76708
3	12744.6	23126	10381.4	4134.7	2.51080
4	10623.6	24072	13448.4	6766.7	1.98744
5	8855.5	25393	16537.5	10631.8	1.55548
6	7381.2	26317	18935.8	11371.5	1.66520

In millions of rubles

(1) Old technology output, obtained by depreciating 1928 values

(2) Total output, from Table V-9

(3) = (2) - (1)

(4) Available new technology capital stock, from Table VI-16, column 6.

(5) = (3) ÷ (4), adjusted productivity for new technology capital.

Table VI-19

Productivity, Livestock-Products, Agriculture

Period	(1) Total X	(2) Productive K	(3)
1	10320	7700	1.34026
2	7567	5800	1.34066
3	6172	5000	1.23440
4	8203	5420.5	1.51333
5	10320	6147.7	1.67868
6	10498	6784.5	1.54736

In millions of rubles

(1) Total output, from Table V-9.

(2) Total capital stock = Old technology capital from Table VI-17 column 1 plus available new technology capital from Table VI-17, column 6.

(3) = (1) ÷ (2), adjusted productivity for old and new technology capital

Table VI-20. Parameter Values: Collectivization versus Reference Solution

Parameter	Collectivization Scenario	Reference Solution
Average Propensity to Consume *		
1929+1930	0.4	0.5
1931+1932	0.4	0.5
1933+1934	0.4	0.5
1935+1936	0.4	0.5
1937+1938	0.4	0.7
1939+1940	0.4	0.7
Fraction of Consumption in Fixed Proportions *		
1929+1930	0.1	0.1
1931+1932	0.1	0.1
1933+1934	0.5	0.5
1935+1936	0.7	0.5
1937+1938	0.85	0.95
1939+1940	0.85	0.95

* These parameters are the same for both workers and peasants.

All other parameters and weights are the same for both solutions.

Table VI-21. Solution Showing Impact of Agricultural Collectivization (Millions of Rubles)

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 1253977.0

ELEMENTS OF THE OBJECTIVE FUNCTION

	SECTORS										
	AF	AL	LP	PG	CG	TC	CD	ID	TD	GS	TOTAL
CAPITAL-42	10044.4	2855.8	7952.7	243801.9	4841.3	22445.8	3976.0	4957.1	2978.4	20720.8	324613.6

	YEAR							
	29630	31632	33634	35636	37638	39640	41642	43644
PEAS CONS	28114.9	19078.2	13830.5	10504.5	10024.9	10956.0		
WORK CONS	8328.3	10884.5	12008.0	10976.3	21628.3	24555.7		

OTHER SUMMARY DATA BY YEAR

	29630	31632	33634	35636	37638	39640	41642	43644
OUTPUT								
OLD TECH	103925.6	95138.3	54300.1	52707.7	19838.0	17836.2		
NEW TECH	13548.1	44917.5	96370.2	181200.7	291152.5	302219.1		
TOTAL	117473.7	140056.3	150670.3	233908.4	310990.5	320055.3		
CAPITAL STOCK								
OLD TECH	49998.0	54206.1	49058.5	44473.4	40390.4	35719.0	33436.8	
NEW TECH	7098.0	17563.5	46681.7	79412.2	142906.2	238330.7	325513.6	
TOTAL	57096.0	71759.7	95740.1	123885.5	183296.5	274049.6	358950.4	
NEW CAPITAL		11249.2	30742.7	35775.8	70625.0	105008.5	109058.5	90352.0
LABOR FORCE								
SUPPLY	56350.0	59527.0	62868.0	65004.0	69480.0	73998.0		
EMPLOYED	49474.6	47842.5	44912.3	49752.6	50119.2	50855.3		
IDLE	6875.4	11684.5	17955.7	15251.4	19360.8	23142.7		
PER CENT	12.4	19.6	28.5	24.3	27.9	31.3		

Trade, Defense and Collectivization

Combining all three influences to approach a composite reconstruction proved much easier than we had expected. Starting with the combined trade and defense solution, Table VI-13 above, the agricultural capital and output modifications were added. The resulting solution had several problems: the sectoral distribution of consumer demand was out of balance, final capital stock was very low, unemployment was a bit high, and required imports were much too stringent in the final period.

The necessary adjustments included lowering the required import ratios to 15% of their initial level, from 20% in trade and defense solution. To make consumption demand more reasonable, the fraction of consumption required to be satisfied in fixed proportion was raised to .4 and .6 in periods three and four (from .3 and .4) and lowered to .8 (from .9) in period six. All other parameters, including the objective function weights, are identical with those in the rearmament solution (table VI-11) and the defense and trade solution (Table VI-13).

The composite reconstruction, combining trade, rearmament and collectivization is presented in Table VI-22. Note that here the capital stock figures do not include military hardware. There are three general points to be made regarding this solution. First, capital stock hold up very well. Second, the sharp fall in consumption and rise in unemployment in period three appear to be unavoidable; efforts to alter the model solution to alleviate this damage were not successful for moderate costs in other objectives. Third, the very small increment in capital stock in 1941-42 reflects the diversion of resources away from capital formation and into defense procurement.

Table VI-22. Trade, Defense, and Collectivization: the Composite Reconstruction
(Millions of Rubles)

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 752754.5

ELEMENTS OF THE OBJECTIVE FUNCTION

SECTORS

	AF	MC	CP	P.	CG	TC	OD	TI	TO	SS	TOTAL
CAPITAL-42	10044.4	2577.7	11717.1	75530.3	9951.7	30333.0	2455.7	5236.1	3365.2	43343.1	195640.4

YEAR

	29530	31532	33534	35536	37538	39540	41542	43544
PEAS CONS	30004.5	21815.7	9532.1	4771.4	10057.9	10710.5		
WORK CONS	7743.1	9921.2	11293.7	18445.1	22218.8	25424.5		

OTHER SUMMARY DATA BY YEAR

	29530	31532	33534	35536	37538	39540	41542	43544
OUTPUT								
OLD TECH	101052.4	99574.3	61757.0	52707.7	42711.0	17835.2		
NEW TECH	13548.1	43938.2	91750.5	173257.5	254655.3	305777.9		
TOTAL	114600.4	143516.0	153735.5	235975.3	307376.1	324514.0		
CAPITAL STOCK								
OLD TECH	59998.0	54205.1	49054.5	44473.4	40380.4	35719.0	33445.0	
NEW TECH	7008.0	17553.5	44024.5	80798.3	124225.3	202354.4	195540.5	
TOTAL	67006.0	71759.7	93083.1	125271.6	164605.6	237093.4	229077.3	
NEW CAPITAL		11259.2	28125.5	40572.3	50535.4	88431.4	8924.7	55235.7
LABOR FORCE								
SUPPLY	55350.0	59527.0	62850.0	65004.0	69640.0	73994.0		
EMPLOYED	47545.9	45720.3	41114.0	48455.4	50942.4	52125.0		
IDLE	7734.1	12797.2	21755.0	17537.5	18597.5	21873.0		
PER CENT	14.0	21.5	34.5	26.5	26.8	29.5		

Comparing These Solutions with the Actual Record

How closely does our composite reconstruction, reflecting the combined impacts of collectivization, rearmament, and world depression, correspond to the actual historical record? In many respects we cannot be sure, since important aspects of the record remain uncertain. But some overall checks are available, and they indicate that our composite reconstruction matches up fairly closely with the historical record. For example, comparison of the economy-wide gross output totals in our composite reconstruction with those compiled above in chapter V and displayed in Table V-9 demonstrates that our estimates clearly have the right dimensions. Data for the six periods appear in the first two lines of the gross output panel in Table VI-23, where it will be seen that our composite reconstruction starts out slightly below the historical level but catches up and surpasses it.

This higher growth rate can be traced to two influences. First, the optimizing algorithum has certain advantages that planners at the time were unlikely to have had. This supra-normal efficiency we would expect to lead to a higher growth rate. But it also leads to slack capacity in some sectors in the first two periods; unaffected by the inertia which haunts real economic systems, KAPROST does not produce anything it cannot use! Second, as noted above, many of the negative impacts on the Soviet economy - the purges and terror, the transportation bottleneck, the initial overinvestment and subsequent waste - were not quantifiable for inclusion in KAPROST. While some of these may have been picked up in our data (the agricultural output and capital stocks, for instance), failure to capture them fully will lead to better performance in the model than in real life.

A second confirmation of our composite reconstruction comes from the correspondence between its capital stock series and the most reliable available estimate of Societ capital stocks. We show in the first line of the panel on capital stocks in Table VI-23 the index for gross capital in 1928 prices compiled by Moorsteen and Powell (The Soviet Capital Stock, 1928-1962, Table T-28, p. 322), chained to our 1928 ruble figure. The composite reconstruction tracks the Moorsteen-Powell index closely, though again our estimates are somewhat below the actual record in the early years and somewhat above it at the end.

The drastic fall in consumption displayed by our composite reconstruction from 38 billion rubles in 1929 and 1930 to 32 billion in the next two years and only 21 billion in 1933 and 1934, cannot be checked against official or Western estimates, since no continuous estimates are available. Professor Chapman long ago demonstrated conclusively, however, that the non-agricultural real wage in 1937, after substantial recovery from the most difficult years around 1933, was 17% below its 1928 level (in terms of the 1928 price structure), or 43% below its 1928 level (in terms of the 1937 price structure). Cf. Janet G. Chapman, Real Wages in Soviet Russia Since 1928 (1963), pp. 145-46.

Perhaps interactions within the composite reconstruction that push its first period total consumption about the 34.4 billion rubles of the reference solution should be discounted as unrealistic; perhaps even the rise of the reference solution figure from 30.5 billion in the base period (twice in 1928 level) should be treated as unlikely. These increases reflect KAPROST's dexterity in distributing output. As capital investment is limited by capacity bottlenecks in the construction sector, extra output from the agricultural, housing and consumer goods sectors is delivered to consumers. A more sophisticated

Table VI-23. Comparing Solutions -- Results for Gross Output and Total Capital Stocks, By Period, in Billions of Rubles at Base Period Prices

	P E R I O D						
GROSS OUTPUT	1929+ 1930	1931+ 1932	1933+ 1934	1935+ 1936	1937+ 1938	1939+ 1940	
Actual (Table V-9)	127	151	169	231	281	307	
Composite (Table VI-22)	115	139	154	236	307	324	
Agricultural Collectivization (Table VI-21)	117	140	161	244	[illegible]1	320	
Depression + Rearmament (Table VI-13)	119	148	171	250	[illegible]1	402	
Rearmament (Table VI-11)	121	149	167	252	[illegible]0	419	
World Depression (Table VI-5)	121	149	182	257	330	407	
Reference Solution Table IV-19)	122	149	182	258	332	406	
TOTAL CAPITAL STOCK, AT START OF YEAR	1929	1931	1933	1935	1937	1939	1941
Actual	67.3	80.5	100.9	123.5	160.2	202.6	265.9
Composite							
Excluding defense capital	67.1	71.8	93.1	125.3	164.6	239.1	229.1
Including defense capital	67.1	71.8	93.1	128.3	184.3	287.9	337.9
Agricultural Collectivization	67.1	71.8	95.7	123.9	183.3	273.0	358.1
Depression + Rearmament							
Excluding defense capital	65.7	74.6	98.0	125.5	171.1	244.7	262.3
Including defense capital	65.7	74.6	98.0	128.5	190.8	293.5	371.1
Rearmament							
Excluding defense capital	65.7	74.6	96.2	127.0	174.5	250.7	276.4
Including defense capital	65.7	74.6	96.2	130.0	194.2	299.5	385.2
World Depression	65.7	74.6	102.4	121.8	[illegible].4	244.9	324.2
Reference Solution	65.7	74.6	102.5	122.1	[illegible].5	248.1	327.4

Table VI-24. Comparing Solutions -- Results for Total Consumption and Unemployment, By Period, in Billions of Rubles at Base-Period Prices, and Percent Unemployed

	P E R I O D					
TOTAL CONSUMPTION	1929+ 1930	1931+ 1932	1933+ 1934	1935+ 1936	1937+ 1933	1939+ 1940
Composite (Table VI-22)	37.7	31.7	20.9	27.3	32.3	36.3
Agricultural Collectivization (Table VI-21)	36.4	30.0	25.8	29.6	31.7	35.6
Depression + Rearmament (Table VI-13)	36.1	35.6	32.3	31.1	37.8	47.1
Rearmament (Table VI-11)	36.2	36.2	27.5	30.8	38.4	48.4
World Depression (Table VI-5)	34.7	33.4	40.4	40.6	66.6	82.6
Reference Solution (Table IV-19)	34.4	33.1	41.0	40.6	66.7	82.3
UNEMPLOYMENT (PERCENT)						
Composite	13.9	21.5	34.5	26.6	26.8	29.6
Agricultural Collectivization	12.4	19.6	28.6	24.3	27.9	31.3
Depression + Rearmament	9.3	13.1	14.2	4.9	7.4	0.0
Rearmament	8.7	12.4	23.2	7.7	7.0	0.0
World Depression	8.5	12.0	0.7	0.0	0.0	0.0
Reference Solution	7.8	11.6	0.0	0.0	0.0	0.0

model with inventory behavior might have held back some of this for use in later periods, especially the producer goods. Alternatively, a less efficient economic system might have lost some of it through waste.

In any case, the fall from 30.5 billion in the late 1920's to 20.9 billion in 1933 and 1934 represents a 31.5% shrinkage in real consumption. If the 20.9 billion is compared with the third period level of 41.0 billion attained under the problem-free conditions of the reference solution, the implication is a 49% shortfall in comparison to what might have been.

Another tragic feature of the composite reconstruction is the massive volume of unemployed labor it involves. The unemployment is organically linked to the shrinkage in real consumption. Since we have maintained the same physical labor productivities throughout all the tests from the reference solution on, the successive constrictions on the economy have made more and more labor superfluous. The unemployment panel on Table VI-24 shows the results. By comparison with the reference solution, which made use of all available labor after the structural shifts of the first two periods were completed, rearmament altered resource use in a way that generated unemployment in periods three, four, and five as well. But the impact of agricultural collectivization was far more severe, making between 24% and 31% of the total labor force unnecessary. Combining collectivization with world depression and rearmament, our composite reconstruction generates unemployment levels running from 14% in the first period to 34.5% in the third, 27% in the fourth and fifth, and 30% at the end of the decade.

Since by constitutional definition unemployment did not exist in the USSR, government policy kept the whole labor force at work: on payrolls in

non-agricultural occupations or in sovkhozy, as members of kolkhozy, or in corrective labor camps. Average labor productivity per person in physical terms fell far enough below its potential to absorb the superfluous labor. Massive unemployment was thus camouflaged, by contrast with the explicitly exposed unemployment in the West during the same period.

The results displayed in Tables VI-23 and VI-24 reveal instructive contrasts. Beginning at the bottom of each panel, one can proceed upward from the reference solution - our hypothetical best case - step by step to the composite reconstruction, noting which factors had the strongest impact. Inspection shows very clearly that agriculatural collectivization dealt the most serious blow against the economy, far more crippling than the two external factors of rearmament and world depression. The evidence is especially vivid in terms of household consumption. Total household consumption over these twelve years comes to 298 billion rubles in the reference solution; world depression leaves the total unchanged. Rearmament lowers total consumption by 27%, to 218 billion, and the two exogenous factors in combination have the effect of restricting consumption to 220 billion. But collectivization of agriculture reduces the total by 37%, to 189 billion, and our composite reconstruction shows a twelve-year total for household consumption of 186 billion rubles.

The loss of draft animals and productive livestock did far more than reduce the flow of livestock products to the population. It forced industry to deliver tractors and other agricultural machinery to field-crops agriculture more promptly than had been intended, thus making non-agricultural capital formation more difficult. It lowered labor productivity in agriculture directly, and indirectly throughout the economy as well. One sees this in Table VI-23,

where, though the total capital stock does not seem severly reduced by the imposition of collectivization, gross output in 1939 and 1940 is 25% lower in solutions including collectivization than in any of the others. The capital has been delivered in less productive uses, and the shift is obtained also at the cost of severly reduced consumption.

Probably the most important consequence of collectivization, though it is not directly measurable by KAPROST, was the political tension and pressure that this "second revolution" spread throughout Soviet society, culminating in political purges and mass terror. This is the tragic human story that underlies the laconic figures in our results.

To facilitate comparisons between our composite reconstruction, which is meant to approximate what actually happened, and the reference solution set forth at the end of chapter IV, we offer some overall data on GNP components and shares in Table VI-25. Several striking contrasts are evident. The total GNP in our composite reconstruction is smaller than in the reference solution over all six periods, as is only to be expected. The shortfall is modest at first, but it is 15% in the 4th period, 11% in the 5th period, and 21% in the 6th period, as the negative developments impose their combined effects. Consumption suffers markedly, as we have seen, but these sacrifices do not serve to make investment larger in the composite reconstruction than in the reference solution. Collectivization and rearmament combine to hold investment down, especially in the last two years, when procurement rises rapidly and fixed capital formation falls from 70 to 21 billion rubles.

The share of consumption in GNP declines from its starting point in both solutions, as resources are shifted into capital formation. But the belt-tightening is more severe in the composite reconstruction, where consumption

Table VI-25. Comparison of GNP and Its Components in the Composite Reconstruction and in the Reference Solution

	PERIOD 1929+ 1930	1931+ 1932	1933+ 1934	1935+ 1936	1937+ 1938	1939+ 1940
BILLIONS OF RUBLES						
Consumption						
Composite Reconstruction	37.7	31.7	20.9	27.3	32.3	36.3
Reference Solution	34.4	33.2	41.0	40.6	66.7	82.4
Investment						
Composite Reconstruction	15.3	31.1	42.9	59.7	69.9	20.7
Reference Solution	20.0	33.7	41.8	79.5	79.4	97.2
Defense Procurement						
Composite Reconstruction	---	---	3.0	17.0	31.0	64.9
Reference Solution	---	---	---	----	----	----
Government Services						
Composite Reconstruction	10.9	12.1	14.7	12.5	12.0	22.7
Reference Solution	7.7	10.1	12.5	14.9	17.3	19.7
Exports						
Composite Reconstruction	2.0	2.3	1.9	1.5	1.3	1.1
Reference Solution	1.7	2.3	3.0	3.6	4.2	4.8
Gross National Product						
Composite Reconstruction	62.6	77.0	86.2	129.4	167.3	171.9
Reference Solution	65.2	81.1	101.9	145.6	178.7	218.8
PERCENT SHARES						
Consumption						
Composite Reconstruction	60.2	41.2	24.2	21.1	19.3	21.1
Reference Solution	52.8	40.9	40.2	27.9	37.3	37.7
Investment						
Composite Reconstruction	24.4	40.4	49.8	46.1	41.8	12.0
Reference Solution	30.7	41.6	41.0	54.6	44.4	44.4
Defense Procurement						
Composite Reconstruction	0.0	0.0	3.5	13.1	18.5	37.8
Government Services						
Composite Reconstruction	10.9	12.1	14.7	12.5	12.0	22.7
Reference Solution	11.8	12.5	12.3	10.2	9.7	9.0
Exports						
Composite Reconstruction	3.2	3.0	2.2	1.2	0.7	0.6
Reference Solution	2.6	2.8	2.9	2.5	2.3	2.2

accounts for only one-fifth of the GNP in the last three periods. This extraordinarily low share excludes public consumption, i.e., health care, education, and municipal services, which account for from 11% to 23% of the GNP, so it is not quite so shocking. Nevertheless it is clear that the Soviet people bore a very heavy burden during this period. Half the GNP was channeled into accumulation in 1933 and 1934 under the composite reconstruction, but the investment share fell off to 42% in the fifth period and dropped to 12% in the sixth, as defense procurement rose to account for more than a third of the GNP in 1939 and 1940.

For those who may wish to examine further details, sector by sector and period by period, we conclude this chapter by reproducing the five reports generated by KAPROST for the composite reconstruction. These are the specific, concrete estimates of output and resource use that should be compared with available independent evidence in appraising the accuracy of the composite reconstruction.

ıble VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

SUMMARY

VALUE OF THE OBJECTIVE FUNCTION: 742749.5

ELEMENTS OF THE OBJECTIVE FUNCTION

	SECTORS										
	AF	AL	EP	PG	CG	TC	CO	HO	TO	GS	TOTAL
PITAL-42	10044.4	2579.9	11917.1	74530.3	5451.9	30483.0	2855.7	5234.1	3945.2	48388.1	195640.4

	YEAR							
	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
AS CONS	30004.5	21815.9	9532.1	3791.8	10047.9	10910.5		
RK CONS	7743.1	9921.2	11293.7	18485.1	22218.8	25424.5		

OTHER SUMMARY DATA BY YEAR

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
TPUT								
OLD TECH	101052.4	89578.3	51957.0	52707.7	42911.9	17835.2		
NEW TECH	13548.1	43938.2	91759.5	173257.5	254454.3	305777.8		
TOTAL	114500.4	133516.9	153735.5	235975.3	307376.1	324514.0		
PITAL STOCK								
OLD TECH	59998.0	54206.1	49058.5	44473.4	40180.4	35719.0	33436.9	
NEW TECH	7098.0	17553.5	44024.5	80798.3	124225.3	202364.4	195640.4	
TOTAL	57096.0	71759.7	93083.1	125271.6	164605.6	239083.4	229077.3	
W CAPITAL		11249.2	28125.5	40472.3	50505.4	88331.4	9824.7	55236.7
BOR FORCE								
SUPPLY	55350.0	59527.0	52859.0	65004.0	69480.0	73999.0		
EMPLOYED	47645.9	45729.8	41114.0	43455.4	50882.4	52125.0		
IDLE	7704.1	12797.2	21755.0	17537.5	18597.5	21873.0		
PER CENT	13.9	21.5	34.5	26.5	26.8	29.5		

Table VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

SUMMARY, CONT'D

OLD TECHNOLOGY OUTPUT

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
AF	18341.0	15280.3	12744.7	10523.5	8955.5	7381.7		
AL	9396.6	5803.3	5553.1	5554.0	5210.5	4470.0		
LP	1083.5	1179.0	855.5	777.3	697.0	526.7		
PS	30796.0	35739.2	22505.1	20239.1	18200.4	0.0		
CG	3038.7	1951.7	4555.3	9923.0	0.0	0.0		
TC	5548.1	5250.0	3435.8	3195.1	2970.4	2751.5		
CO	8509.1	9200.3	0.0	0.0	0.0	0.0		
MD	3256.1	3016.3	2775.0	2554.5	2358.4	2187.3		
TD	5408.0	4895.1	4402.8	3985.1	3508.8	0.0		
GS	5553.8	5195.5	5115.7	4920.3	0.0	0.0		

NEW TECHNOLOGY OUTPUT

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
AF	4410.1	8300.9	7172.2	12517.5	16537.5	18935.8		
AL	923.4	755.8	514.9	989.1	2503.5	4137.8		
LP	335.1	1559.1	3540.2	7191.2	11144.5	15959.2		
PS	2234.5	17390.3	34457.5	41575.8	121506.0	157907.3		
CG	2504.0	4457.1	5588.3	5541.0	24512.2	32444.9		
TC	230.2	0.0	1890.8	5440.3	8555.9	10774.5		
CO	1712.5	11377.5	25115.5	30975.5	48805.0	12850.0		
MD	340.5	750.3	870.0	508.5	595.2	1165.5		
TD	635.5	773.2	773.9	5573.1	9202.7	14471.0		
GS	222.2	3032.5	7522.3	11364.7	20090.0	39011.0		

Table VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

SUMMARY, CONT'D

NEW TECHNOLOGY CAPITAL STOCK

	29530	31532	33534	35536	37538	39540	41542	43544
AF	2591.0	3340.7	2455.5	7950.9	12274.5	11746.9	10044.4	
AL	649.0	547.7	501.4	755.4	1956.2	3141.5	2577.0	
FP	248.0	503.0	3515.0	5178.6	9993.4	13252.0	11017.1	
PS	524.0	3030.2	11701.5	22785.4	31793.7	71012.0	74630.3	
CS	452.0	1103.4	1098.3	1519.1	5054.4	5001.3	5451.9	
TC	549.0	2593.2	6579.1	10274.4	26317.5	42775.4	30493.0	
CO	131.0	570.5	2504.4	3471.3	4095.1	3417.5	2855.7	
HO	1404.0	3850.7	3597.8	3334.1	3098.4	5532.3	5239.1	
TO	154.0	221.7	194.7	2333.1	2472.9	4380.3	3945.2	
GS	246.0	1442.5	11470.2	13311.3	25352.5	50994.8	48399.1	

NEW CAPITAL STOCK INCREMENTS

	29530	31532	33534	35536	37538	39540	41542	43544
AF		1125.2	0.0	5508.3	5476.1	1251.3	0.0	3733.5
AL		0.0	0.0	322.7	1215.0	1553.2	0.0	914.1
FP		380.0	3073.8	2756.6	3319.3	4404.3	0.0	3815.0
PS		2552.0	8935.3	12105.5	10999.7	51797.1	9824.7	21119.5
CS		697.0	0.0	401.0	4363.9	431.9	0.0	1555.5
TC		2075.0	5070.1	13130.1	3885.5	7866.0	0.0	3454.9
CO		551.0	1944.2	1378.7	1199.5	0.0	0.0	1331.0
HO		2555.0	0.0	0.0	0.0	2752.9	0.0	1303.5
TO		74.0	0.0	2203.2	526.1	2153.3	0.0	1137.4
GS		1200.0	10101.2	2425.2	13729.2	25055.0	0.0	11403.2

Table VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

SUMMARY, CONT'D

OLD TECHNOLOGY CAPITAL CAPACITY CONSTRAINT DUAL

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
AF	-4.882	-4.022	-4.447	-3.352	-8.711	-27.822		
AL	-1.542	-1.307	-1.247	-3.165	-0.445	-0.370		
EP	0.000	-15.004	-5.355	-0.765	-4.341	-0.594		
PG	-16.780	-12.427	-14.572	-7.631	-4.203	0.000		
CG	0.000	0.000	0.000	-3.397	0.000	0.000		
TC	-0.549	-0.497	-11.703	-4.082	-2.458	-1.230		
CO	0.000	-702.174	0.000	0.000	0.000	0.000		
HO	-0.349	-0.293	-0.257	-0.246	-0.091	-2.352		
TO	-27.540	-22.579	-18.207	-15.256	-0.071	0.000		
GS	0.000	-0.172	-20.837	-17.509	0.000	0.000		

NEW TECHNOLOGY CAPITAL CAPACITY CONSTRAINT DUAL

	29&30	31&32	33&34	35&36	37&38	39&40	41&42	43&44
AF	-3.226	-4.312	-3.765	-2.454	-5.965	-21.590		
AL	-1.620	-1.225	-0.705	-2.768	-0.675	-1.849		
EP	-0.004	-22.020	-4.513	-4.175	-3.134	-0.661		
PG	-5.974	-5.544	-9.275	-6.321	-2.787	0.000		
CG	-0.757	0.000	-3.375	-6.535	-2.285	-1.311		
TC	-0.055	0.000	-10.304	-7.130	-2.047	-1.277		
CO	-13.102	-759.405	-3.470	-2.978	-5.592	0.000		
HO	-0.425	-0.351	-0.003	-0.111	0.000	-3.709		
TO	-7.427	-7.773	-7.803	-7.284	-1.176	-4.120		
GS	-0.207	0.000	-10.425	-12.169	-0.027	-3.374		

Table VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

SUMMARY, CONT'D

DISTRIBUTION RELATIONSHIP DUAL VALUE

	29630	31632	33634	35636	37638	39640	41642	43644
AF	-2.580	-2.120	-2.531	-2.398	-5.531	-20.134		
AL	-2.580	-2.120	-2.531	-3.507	-3.315	-11.122		
EP	-0.757	-8.477	-10.101	-7.955	-4.310	-2.517		
PS	-2.580	-2.120	-7.741	-5.581	-2.685	-3.137		
CS	-3.170	-2.753	-7.203	-8.220	-5.531	-13.543		
TC	-2.580	-2.120	-38.503	-27.333	-7.500	-10.431		
CO	-2.181	-40.005	-3.202	-2.531	-1.905	-3.252		
HO	-2.580	-2.120	-2.531	-2.398	-0.737	-17.118		
TD	-2.580	-2.120	-2.531	-2.398	-0.534	-2.035		
GS	-1.055	-1.575	-25.532	-16.940	-2.027	-7.953		

OPTIONAL CONSUMPTION

	29630	31632	33634	35636	37638	39640	41642	43644
AF	8307.7	9330.5	5781.5	2755.8	0.0	0.0		
AL	5781.8	4259.1	730.3	0.0	0.0	0.0		
EP	0.0	0.0	0.0	0.0	0.0	0.0		
PS	8052.5	5741.9	0.0	0.0	0.0	0.0		
CS	0.0	0.0	0.0	0.0	0.0	0.0		
TC	2001.8	658.5	0.0	0.0	0.0	0.0		
CO	0.0	0.0	0.0	0.0	0.0	0.0		
HO	3250.8	3459.5	2745.3	1502.6	0.0	0.0		
TD	5358.2	5053.9	3288.4	5552.8	5453.3	7257.0		
GS	0.0	0.0	0.0	0.0	0.0	0.0		

Table VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

YEAR IS 1930

FINAL DEMAND REPORT

	DELIVERING SECTORS										
	AF	AL	PP	PG	CG	FC	CD	HD	TD	GS	TOTAL	DUAL
INTERINDUSTRY DEMAND												
	13224.1	1291.3	1413.5	25725.1	5483.5	3311.4	0.0	0.0	0.0	0.0	51354.0	
CONSUMPTION												
PEASANTS	497.7	1344.1	0.0	12.1	712.5	37.5	0.0	255.3	451.0	0.0	3009.4	0.000
WORKERS	74.5	112.2	0.0	5.3	229.5	27.0	0.0	133.5	224.3	0.0	774.3	-0.031
OPTIONAL	8407.7	5931.8	0.0	4052.5	0.0	2001.3	0.0	3250.8	5358.[illegible]	0.0	33772.0	
TOTAL	8980.0	3134.1	0.0	4070.0	942.1	2065.4	0.0	3639.5	6033.[illegible]	0.0	37747.6	
INVESTMENT												
FIRST YEAR	0.0	0.0	0.0	2597.1	0.0	0.0	4147.4	0.0	0.0	0.0	6744.5	
2ND YEAR	0.0	158.5	0.0	3672.8	0.0	0.0	4720.2	0.0	0.0	0.0	8551.5	
TOTAL	0.0	158.5	0.0	6269.9	0.0	0.0	8867.6	0.0	0.0	0.0	15296.0	
STOCK GROWTH												
OLD TECH	343.4	0.0	0.0	215.0	99.4	0.0	1127.1	0.0	0.0	0.0	1785.8	
NEW TECH	78.0	0.0	0.0	40.7	438.8	0.0	227.0	0.0	0.0	0.0	784.4	
TOTAL	421.3	0.0	0.0	257.5	538.2	0.0	1354.1	0.0	0.0	0.0	2571.2	
GOVERNMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6786.0	6786.0	
FOREIGN TRADE												
EXPORTS	245.0	741.0	0.0	855.0	151.0	0.0	0.0	0.0	0.0	0.0	1993.0	
IMPORTS:												
OLD TECH	16.9	9.1	0.0	130.2	3.7	0.0	0.0	0.0	0.0	0.0	159.8	
NEW TECH	1.6	0.3	0.0	7.0	3.2	0.0	0.0	0.0	0.0	0.0	13.0	
OPTIONAL	0.0	0.0	0.0	0.0	1575.2	0.0	0.0	0.0	0.0	0.0	1575.2	
TOTAL	18.4	9.5	0.0	138.1	1582.1	0.0	0.0	0.0	0.0	0.0	1748.0	
NET EXPORT	226.6	731.5	0.0	707.9	-1421.1	0.0	0.0	0.0	0.0	0.0	245.0	-3.170
FOREIGN TRADE CREDITS										-245.0		
FINAL DEMAND TOTALS												
	9527.9	9028.2	0.0	15305.3	59.2	2065.4	10221.7	3635.5	6043.5	6786.0	62645.6	
GROSS VALUE OF OUTPUT												
OLD TECH	18341.9	9395.5	1083.5	39795.0	3038.7	5548.1	8509.1	3255.1	5408.0	6553.8	101052.4	
NEW TECH	4410.1	923.5	335.1	2235.5	2504.0	230.2	1712.5	340.5	535.5	222.2	13548.1	
TOTAL	22752.0	10323.0	1418.5	42031.4	5542.7	5478.2	10221.7	3595.5	6043.5	6786.0	114600.4	
DUAL VALUES OF DISTRIBUTION CONSTRAINTS												
	-2.540	-2.540	-0.757	-2.540	-3.170	-2.540	-2.181	-2.580	-2.590	-1.065		

Table VI-26. Solution Values for the Composite Reconstruction (Millions of Rubles)

YEAR IS 1990

RESOURCE UTILIZATION REPORT

PRODUCING SECTORS

	AF	NL	EP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	TO	GS	TOTAL
CAPITAL STOCK											
OLD TECHNOLOGY											
STOCK	7599.0	7011.0	559.0	2351.0	2485.0	10759.0	535.0	22049.0	453.0	5519.0	59998.0
UTILIZED	7599.0	7011.0	459.2	2351.0	556.2	10759.0	401.7	22049.0	453.0	5519.8	57844.5
PERCENT	100.0	100.0	82.5	100.0	22.4	100.0	74.9	100.0	100.0	100.0	96.4
CAPACITY CONSTRAINT											
DUAL VALUE	-4.882	-1.542	0.000	-15.780	0.000	-0.549	0.000	-0.349	-27.540	0.000	
NEW TECHNOLOGY											
STOCK	2591.0	549.0	248.0	524.0	452.0	549.0	131.0	1404.0	154.0	245.0	7098.0
AVAILABLE	2591.0	539.0	248.0	524.0	452.0	549.0	131.0	1404.0	164.0	245.0	
UTILIZED	2591.0	649.0	248.0	524.0	452.0	549.0	131.0	1404.0	154.0	255.0	7098.0
PERCENT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
CAPACITY CONSTRAINT											
DUAL VALUE	-3.226	-1.620	-0.004	-5.074	-0.957	-0.355	-13.102	-0.425	-0.427	-0.207	
LABOR FORCE											
OLD TECH	28983.5	2900.3	18.2	2375.1	827.2	1031.1	1373.3	726.9	1019.4	2460.9	42636.5
NEW TECH	4209.3	192.1	1.9	99.5	280.3	27.3	101.5	36.3	44.5	27.3	5009.1
TOTAL	33192.8	3092.4	20.1	2474.6	1107.5	1058.4	1474.8	763.2	1063.9	2488.2	47645.6

TOTAL LABOR SUPPLY: 55950 EMPLOYED: 47645 PERCENT EMPLOYED: 85.1 DUAL VALUE: 0.000

Table VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

YEAR IS 1932

FINAL DEMAND REPORT

DELIVERING SECTORS

	AF	[illegible]	[illegible]	[illegible]	[illegible]	TC	[illegible]	[illegible]	TD	[illegible]	TOTAL	DUAL
INTERINDUSTRY DEMAND	13109.1	1230.1	2739.0	33577.9	5350.0	4520.4	0.0	0.0	0.0	0.0	51534.4	
CONSUMPTION												
PEASANTS	351.7	757.2	0.0	8.8	515.1	27.3	0.0	174.3	327.7	0.0	2131.6	0.000
WORKERS	75.4	153.7	0.0	9.0	294.1	34.5	0.0	123.7	287.4	0.0	992.1	-0.001
OPTIONAL	7330.6	4259.1	0.0	5781.9	0.0	659.5	0.0	3457.5	5053.	0.0	24553.5	
TOTAL	7757.9	5172.0	0.0	5799.7	812.2	730.4	0.0	3755.5	5667.	0.0	31737.1	
INVESTMENT												
FIRST YEAR	0.0	275.9	0.0	4539.5	0.0	0.0	4713.4	0.0	[illegible]	0.0	9735.4	
2ND YEAR	0.0	0.0	0.0	8233.1	0.0	0.0	13148.0	0.0	[illegible]	0.0	21361.1	
TOTAL	0.0	275.9	0.0	12920.5	0.0	0.0	17861.3	0.0	0.0	0.0	31096.8	
STOCK GROWTH												
OLD TECH	285.2	0.0	0.0	175.0	53.9	0.0	1210.9	0.0	0.0	0.0	1765.0	
NEW TECH	146.9	0.0	0.0	324.9	742.8	0.0	1508.1	0.0	0.0	0.0	2762.7	
TOTAL	433.1	0.0	0.0	510.9	846.5	0.0	2728.1	0.0	0.0	0.0	4527.7	
GOVERNMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9270.0	9270.0	
FOREIGN TRADE												
EXPORTS	237.0	357.0	0.0	1592.0	149.0	0.0	0.0	0.0	0.0	0.0	2335.0	
IMPORTS:												
OLD TECH	14.0	5.5	0.0	117.1	2.4	0.0	0.0	0.0	0.0	0.0	140.0	
NEW TECH	3.0	0.3	0.0	63.1	5.7	0.0	0.0	0.0	0.0	0.0	72.1	
OPTIONAL	0.0	0.0	0.0	0.0	1770.9	0.0	0.0	0.0	0.0	0.0	1770.9	
TOTAL	17.0	5.9	0.0	180.1	1779.0	0.0	0.0	0.0	0.0	0.0	1983.0	
NET EXPORT	270.0	350.1	0.0	1411.9	-1590.0	0.0	0.0	0.0	0.0	0.0	352.0	-2.753
FOREIGN TRADE CREDITS										-352.0		
FINAL DEMAND TOTALS	10491.0	5328.0	0.0	20059.1	68.9	730.4	20549.4	3755.5	5667.3	9270.0	75932.6	
GROSS VALUE OF OUTPUT												
OLD TECH	15239.3	6800.3	1179.9	35788.2	1951.7	5250.9	9207.8	3015.3	4675.1	6175.5	89578.8	
NEW TECH	8300.0	756.8	1559.1	17849.8	4467.1	0.0	11370.6	750.3	773.2	3092.5	48938.2	
TOTAL	23539.1	7557.1	2739.0	53637.9	6418.8	5250.9	20589.4	3765.5	5448.3	9270.0	138516.9	
DUAL VALUES OF DISTRIBUTION CONSTRAINTS	-2.129	-2.129	-8.577	-2.129	-2.753	-2.129	-40.006	-2.129	-2.129	-1.575		

Table VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

YEAR IS 1932

RESOURCE UTILIZATION REPORT

PRODUCING SECTORS

	AF	AI	FP	MG	CG	TC	CD	HJ	TJ	SS	TOTAL
CAPITAL STOCK											
OLD TECHNOLOGY											
STOCK	6259.3	5365.5	510.7	2572.8	2239.5	10188.4	434.7	20375.0	419.2	5210.0	54206.1
UTILIZED	5259.3	5212.3	510.7	2572.8	357.2	10188.4	434.7	20375.0	419.2	5210.0	51551.6
PERCENT	100.0	97.2	100.0	100.0	16.0	100.0	100.0	100.0	100.0	100.0	95.1
CAPACITY CONSTRAINT											
DUAL VALUE	-4.022	-1.307	-16.094	-12.427	0.000	-0.497	-702.175	-0.283	-22.598	-0.172	
NEW TECHNOLOGY											
STOCK	4340.7	597.7	503.0	4030.2	1104.4	2598.2	570.5	3350.7	221.7	1452.5	17553.5
AVAILABLE	3003.1	597.7	490.0	2255.6	899.3	2059.7	502.2	3033.9	199.5	1079.8	
UTILIZED	3003.1	597.7	480.0	2254.6	406.4	0.0	502.2	3033.9	199.5	1074.8	12025.3
PERCENT	100.0	100.0	100.0	100.0	49.7	0.0	100.0	100.0	100.0	99.5	84.8
CAPACITY CONSTRAINT											
DUAL VALUE	-4.312	-1.225	-22.020	-5.544	0.000	0.000	-760.806	-0.351	-7.775	0.000	
LABOR FORCE											
OLD TECH	24159.8	2098.9	19.9	2154.8	531.3	1775.3	1486.4	671.3	922.9	2323.2	36163.6
NEW TECH	7931.5	151.2	4.1	787.0	500.1	0.0	674.2	80.0	54.2	379.0	10566.2
TOTAL	32091.2	2250.1	23.9	2941.8	1031.4	1775.3	2160.6	751.3	977.1	2702.2	46729.8

TOTAL LABOR SUPPLY: 59527 EMPLOYED: 46730 PERCENT EMPLOYED: 78.5 DUAL VALUE: 0.000

Table VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

YEAR IS 1939

FINAL DEMAND REPORT

	DELIVERING SECTORS										
	AF	AL	EP	PS	CS	TC	CO	HO	TD	GS	TOTAL	DUAL
INTERINDUSTRY DEMAND	12472.6	1350.4	4505.7	35737.0	7373.5	5130.7	0.0	0.0	0.0	0.0	67570.3	
CONSUMPTION												
PEASANTS	539.1	1390.7	0.0	15.6	915.0	48.3	0.0	315.0	579.1	0.0	3852.9	0.000
WORKERS	434.5	654.5	0.0	35.6	1330.2	157.7	0.0	585.2	1309.8	0.0	4517.5	-0.845
OPTIONAL	5781.5	739.3	0.0	0.0	0.0	0.0	0.0	2745.8	3288.	0.0	12555.4	
TOTAL	6355.1	2734.5	0.0	52.2	2254.2	205.0	0.0	3547.0	5175.	0.0	20925.7	
INVESTMENT												
FIRST YEAR	0.0	435.1	0.0	4833.3	0.0	0.0	6843.4	0.0	0.	0.0	12111.7	
2ND YEAR	0.0	937.1	0.0	14885.0	0.0	0.0	14944.4	0.0	0.	0.0	30766.4	
TOTAL	0.0	1372.2	0.0	19718.2	0.0	0.0	21787.8	0.0	0.	0.0	42878.2	
STOCK GROWTH												
OLD TECH	238.6	0.0	0.0	122.7	149.4	0.0	0.0	0.0	0.0	0.0	510.6	
NEW TECH	126.8	0.0	0.0	700.1	979.2	0.0	3328.7	0.0	0.0	0.0	5134.8	
TOTAL	365.4	0.0	0.0	822.8	1128.6	0.0	3328.7	0.0	0.0	0.0	5645.4	
GOVERNMENT	0.0	0.0	0.0	3030.0	0.0	0.0	0.0	0.0	0.0	12738.0	15768.0	
FOREIGN TRADE												
EXPORTS	238.0	720.0	0.0	823.0	156.0	0.0	0.0	0.0	0.0	0.0	1937.0	
IMPORTS:												
OLD TECH	11.6	5.3	0.0	73.5	5.6	0.0	0.0	0.0	0.0	0.0	96.2	
NEW TECH	2.6	0.2	0.0	135.0	7.1	0.0	0.0	0.0	0.0	0.0	145.9	
OPTIONAL	0.0	0.0	0.0	0.0	746.0	0.0	0.0	0.0	0.0	0.0	746.0	
TOTAL	14.3	5.5	0.0	208.5	758.6	0.0	0.0	0.0	0.0	0.0	988.0	
NET EXPORT	223.7	714.4	0.0	614.5	-602.6	0.0	0.0	0.0	0.0	0.0	949.0	-9.208
FOREIGN TRADE CREDITS										-949.0		
FINAL DEMAND TOTALS	7344.2	4821.1	0.0	24235.7	2780.2	205.0	25116.5	3547.0	5175.4	12738.0	95156.3	
GROSS VALUE OF OUTPUT												
OLD TECH	12744.7	5553.1	855.6	22536.1	4565.3	3436.8	0.0	2677.0	4402.4	5115.7	61967.0	
NEW TECH	7172.2	618.9	3650.2	38457.5	5588.3	1899.4	25116.5	870.0	773.4	7622.3	91769.6	
TOTAL	19916.8	6172.0	4505.8	60993.7	10153.6	5335.5	25116.5	3547.0	5175.8	12738.0	153736.4	
DUAL VALUES OF DISTRIBUTION CONSTRAINTS	-2.581	-2.591	-10.101	-7.741	-9.209	-38.593	-3.202	-2.581	-2.591	-25.642		

Table VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

YEAR IS 1934

RESOURCE UTILIZATION REPORT

PRODUCING SECTORS

	AF	AL	CP	[illegible]	CS	FC	CY	HD	TD	SS	TOTAL
CAPITAL STOCK											
OLD TECHNOLOGY											
STOCK	5217.5	5032.0	459.3	2313.7	2315.4	3471.0	352.6	14335.0	373.5	4918.3	49058.5
UTILIZED	5217.5	4430.5	458.4	2313.5	935.5	3471.0	0.0	14335.0	373.5	4918.3	45330.3
PERCENT	100.0	88.3	100.0	100.0	41.4	100.0	0.0	100.0	100.0	100.0	95.7
CAPACITY CONSTRAINT											
DUAL VALUE	-4.449	-1.237	-5.355	-14.572	0.000	-11.733	0.000	-0.257	-18.209	-20.839	
NEW TECHNOLOGY											
STOCK	2855.0	501.4	3615.0	11701.5	1008.8	5578.1	2504.4	3547.9	199.7	11473.2	44024.6
AVAILABLE	2856.5	501.4	2593.0	7020.8	1008.8	5357.1	1921.2	3547.8	199.7	8439.0	
UTILIZED	2856.5	501.4	2593.0	7020.8	1008.8	5357.1	1921.2	3547.8	199.7	8439.0	35586.0
PERCENT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
CAPACITY CONSTRAINT											
DUAL VALUE	-3.765	-0.795	-4.513	-7.275	-3.376	-10.394	-3.470	-0.003	-7.903	-19.426	
LABOR FORCE											
OLD TECH	20138.0	1714.0	14.5	1355.1	1242.8	1175.0	0.0	618.0	923.0	1718.0	29006.1
NEW TECH	5845.6	122.1	21.2	1595.1	625.5	225.2	1448.0	92.7	54.3	737.2	12107.8
TOTAL	26084.4	1836.0	35.7	3951.1	1868.5	1400.2	1448.0	710.8	899.2	2855.1	41114.0

TOTAL LABOR SUPPLY: 62850 EMPLOYED: 41114 PERCENT EMPLOYED: 65.4 DUAL VALUE: 0.000

Table VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

YEAR IS 1935

FINAL DEMAND REPORT

	DELIVERING SECTORS											
	AF	AL	MP	MS	CS	FC	CO	HO	ED	GS	TOTAL	DUAL
INTERINDUSTRY DEMAND												
	17851.5	1831.9	7358.4	59586.8	11093.0	8182.2	0.0	0.0	0.0	0.0	105553.7	
CONSUMPTION												
PEASANTS	875.1	1835.7	0.0	21.3	1252.8	55.1	0.0	431.2	792.8	0.0	5275.1	-0.273
WORKERS	1066.8	1607.1	0.0	89.9	3289.0	397.1	0.0	1439.3	3213.5	0.0	11031.6	-1.045
OPTIONAL	2755.8	0.0	0.0	0.0	0.0	0.0	0.0	1502.5	6552.	0.0	10911.2	
TOTAL	4697.7	3442.8	0.0	111.2	4540.8	453.2	0.0	3373.1	10557.	0.0	27277.9	
INVESTMENT												
FIRST YEAR	0.0	300.9	0.0	8018.2	0.0	0.0	12992.7	0.0	0.	0.0	21301.9	
2ND YEAR	0.0	1378.1	0.0	15320.7	0.0	0.0	21674.8	0.0	0.	0.0	38393.6	
TOTAL	0.0	1679.1	0.0	23338.9	0.0	0.0	34677.5	0.0	0.	0.0	59695.5	
STOCK GROWTH												
OLD TECH	198.9	0.0	0.0	110.3	324.7	0.0	0.0	0.0	0.0	0.0	633.9	
NEW TECH	221.3	0.0	0.0	1486.5	1163.7	0.0	5298.0	0.0	0.0	0.0	8169.5	
TOTAL	420.2	0.0	0.0	1576.8	1488.4	0.0	5298.0	0.0	0.0	0.0	8803.4	
GOVERNMENT	0.0	0.0	0.0	16995.0	0.0	0.0	0.0	0.0	0.0	16194.0	33189.0	
FOREIGN TRADE												
EXPORTS	186.0	551.0	0.0	652.0	122.0	0.0	0.0	0.0	0.0	0.0	1511.0	
IMPORTS:												
OLD TECH	9.7	6.4	0.0	66.2	12.1	0.0	0.0	0.0	0.0	0.0	94.4	
NEW TECH	4.5	0.4	0.0	288.5	8.5	0.0	0.0	0.0	0.0	0.0	301.9	
OPTIONAL	0.0	0.0	0.0	0.0	658.8	0.0	0.0	0.0	0.0	0.0	658.8	
TOTAL	14.3	6.7	0.0	354.7	679.3	0.0	0.0	0.0	0.0	0.0	1055.1	
NET EXPORT	171.7	544.3	0.0	297.3	-557.3	0.0	0.0	0.0	0.0	0.0	455.9	-8.220
FOREIGN TRADE CREDITS										-455.0		
FINAL DEMAND TOTALS												
	5239.6	5576.1	0.0	42329.1	5471.9	453.2	39975.5	3373.1	10557.2	16194.0	129421.6	
GROSS VALUE OF OUTPUT												
OLD TECH	10623.6	5558.9	777.3	20239.1	9923.9	3195.1	0.0	2554.6	3985.1	4829.3	62707.7	
NEW TECH	12517.5	989.1	7181.2	81676.8	6641.0	5440.3	39975.5	818.5	6573.1	11364.7	173267.6	
TOTAL	23141.1	7548.0	7958.4	101915.9	16565.0	8635.4	39975.5	3373.1	10559.2	16194.0	235975.3	
DUAL VALUES OF DISTRIBUTION CONSTRAINTS												
	-2.378	-3.509	-7.355	-5.681	-8.223	-27.333	-2.531	-2.329	-2.329	-15.940		

Table VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

YEAR IS 1936

RESOURCE UTILIZATION REPORT

PRODUCING SECTORS

	AF	ML	FP	PS	CG	TC	CO	HO	TD	GS	TOTAL
CAPITAL STOCK											
OLD TECHNOLOGY											
STOCK	4399.2	4340.7	412.0	2040.5	1815.3	8835.4	245.0	17335.3	343.6	4642.9	44473.4
UTILIZED	4399.2	4340.7	412.0	2030.6	1816.3	8835.9	0.0	17335.3	343.6	4642.9	44187.3
PERCENT	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	99.4
CAPACITY CONSTRAINT											
DUAL VALUE	-3.352	-3.155	-5.755	-7.631	-1.379	-8.092	0.000	-0.245	-15.256	-12.509	
NEW TECHNOLOGY											
STOCK	7759.8	759.4	5194.4	22745.4	1319.1	13234.4	3471.3	3334.1	2393.1	13311.3	90778.3
AVAILABLE	6294.3	653.5	5314.4	19153.5	1198.8	15340.3	3057.7	3334.1	1722.1	12593.7	
UTILIZED	6294.3	553.5	5314.4	19153.4	1198.8	15340.3	3057.7	3334.1	1722.1	12593.7	59656.5
PERCENT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
CAPACITY CONSTRAINT											
DUAL VALUE	-2.459	-2.753	-4.175	-6.321	-5.535	-7.130	-2.078	-0.111	-7.294	-12.189	
LABOR FORCE											
OLD TECH	16787.1	2027.5	13.0	1409.5	2701.5	1092.4	0.0	570.7	751.4	1810.6	26972.9
NEW TECH	11947.5	195.1	41.9	3501.2	743.5	644.8	2359.3	85.2	457.8	1397.3	21473.4
TOTAL	28734.7	2222.5	54.9	4910.7	3445.1	1737.2	2359.3	655.9	1210.1	3207.9	48455.4

TOTAL LABOR SUPPLY: 66034. EMPLOYED: 48455 PERCENT EMPLOYED: 73.4 DUAL VALUE: 0.000

Table VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

YEAR IS 1938

FINAL DEMAND REPORT

DELIVERING SECTORS

	AF	AL	FP	MG	CG	TC	CF	HO	TO	GS	TOTAL	DUAL
INTERINDUSTRY DEMAND												
	21788.8	1934.5	11842.5	73527.5	14235.7	10815.3	0.0	0.0	0.0	0.0	140109.3	
CONSUMPTION												
PEASANTS	1333.5	2737.2	0.0	32.5	1737.0	100.7	0.0	657.1	1204.2	0.0	8038.2	-0.755
WORKERS	1709.6	2575.4	0.0	144.0	5251.2	620.4	0.0	2305.5	5150.0	0.0	17775.1	-0.634
OPTIONAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6451.	0.0	6453.3	
TOTAL	3043.1	5312.7	0.0	175.5	7178.3	721.1	0.0	2963.6	12811.	0.0	32266.6	
INVESTMENT												
FIRST YEAR	0.0	0.0	0.0	1175.0	0.0	0.0	1180.0	0.0	0.	0.0	2356.0	
2ND YEAR	0.0	353.5	0.0	25418.4	0.0	0.0	41157.6	0.0	0.	0.0	57529.5	
TOTAL	0.0	353.5	0.0	26593.4	0.0	0.0	42338.5	0.0	0.	0.0	59885.4	
STOCK GROWTH												
OLD TECH	155.8	0.0	0.0	99.2	0.0	0.0	0.0	0.0	0.0	0.0	255.0	
NEW TECH	202.4	0.0	0.0	2211.4	4470.5	0.0	6558.4	0.0	0.0	0.0	13442.7	
TOTAL	458.2	0.0	0.0	2310.6	4470.5	0.0	6558.4	0.0	0.0	0.0	13707.7	
GOVERNMENT	0.0	0.0	0.0	31027.0	0.0	0.0	0.0	0.0	0.0	20089.0	51116.0	
FOREIGN TRADE												
EXPORTS	152.0	400.0	0.0	551.0	106.0	0.0	0.0	0.0	0.0	0.0	1310.0	
IMPORTS:												
OLD TECH	8.1	5.0	0.0	59.5	0.0	0.0	0.0	0.0	0.0	0.0	73.7	
NEW TECH	6.0	0.0	0.0	429.2	32.5	0.0	0.0	0.0	0.0	0.0	468.8	
OPTIONAL	44.9	0.0	0.0	0.0	440.7	0.0	0.0	0.0	0.0	0.0	485.6	
TOTAL	59.1	6.0	0.0	488.8	473.3	0.0	0.0	0.0	0.0	0.0	1028.1	
NET EXPORT	102.0	443.1	0.0	72.2	-367.3	0.0	0.0	0.0	0.0	0.0	230.0	-5.631
FOREIGN TRADE CREDITS										-231.0		
FINAL DEMAND TOTALS												
	3604.2	5803.3	0.0	58179.9	11281.5	721.1	48896.7	2963.6	12811.5	20089.0	167266.8	
GROSS VALUE OF OUTPUT												
OLD TECH	8855.5	5210.4	597.0	14200.4	0.0	2270.4	0.0	2358.4	3609.8	0.0	42911.0	
NEW TECH	16537.5	2503.5	11144.5	121535.7	25512.2	9565.9	48896.7	595.2	9202.7	20089.0	264464.3	
TOTAL	25393.0	3713.9	11842.5	135737.3	25512.2	11536.4	48896.7	2953.6	12811.5	20089.0	307376.1	
DUAL VALUES OF DISTRIBUTION CONSTRAINTS												
	-5.631	-3.315	-4.310	-2.585	-5.541	-0.500	-1.906	-0.930	-0.504	-2.027		

Table VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

YEAR IS 1935

RESOURCE UTILIZATION REPORT

PRODUCING SECTORS

	NF	AL	EP	PS	CH	TC	CT	FI	TD	SS	TOTAL
CAPITAL STOCK											
OLD TECHNOLOGY											
STOCK	3625.4	3677.5	357.0	1371.0	1636.1	8186.5	232.7	15365.8	311.1	4442.0	40380.4
UTILIZED	3625.4	3677.5	357.0	1371.0	0.0	8186.5	0.0	15365.8	311.1	0.0	34129.3
PERCENT	100.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0	100.0	0.0	84.5
CAPACITY CONSTRAINT											
DUAL VALUE	-8.711	-0.495	-4.441	-4.203	0.000	-2.454	0.000	-0.081	-0.071	0.000	
NEW TECHNOLOGY											
STOCK	12276.5	1856.2	7733.4	31793.7	6064.4	25810.5	4090.1	3034.4	2472.8	26352.5	124225.3
AVAILABLE	10631.8	1471.3	8247.5	24493.8	4505.3	24153.0	3733.2	3008.4	2374.0	22243.7	
UTILIZED	10631.8	1471.3	8247.5	24493.7	4505.2	24153.0	3733.3	2455.5	2374.0	22243.8	108429.8
PERCENT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	77.2	100.0	100.0	97.4
CAPACITY CONSTRAINT											
DUAL VALUE	-5.865	-0.695	-3.134	-2.787	-2.285	-2.047	-5.592	0.000	-1.176	-0.027	
LABOR FORCE											
OLD TECH	13993.3	1716.3	11.7	1096.8	0.0	1015.6	0.0	527.1	580.2	0.0	19240.6
NEW TECH	15784.4	693.7	64.3	4357.3	2856.2	1015.3	2891.5	63.4	645.1	2470.0	31641.8
TOTAL	29777.7	2410.5	75.5	5453.1	2856.2	2030.9	2891.5	590.5	1325.3	2470.0	50882.4

TOTAL LABOR SUPPLY: 69480 EMPLOYED: 50882 PERCENT EMPLOYED: 73.2 DUAL VALUE: 0.000

Table VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

YEAR IS 1960

FINAL DEMAND REPORT

	DELIVERING SECTORS											
	AF	AL	FP	PS	CS	IC	CO	HO	TO	GS	TOTAL	DUAL
INTERINDUSTRY DEMAND												
	22515.1	2318.0	15595.3	79833.9	18633.6	12735.9	0.0	0.0	0.0	0.0	152704.1	
CONSUMPTION												
PEASANTS	1444.0	3037.4	0.0	35.3	2072.9	109.4	0.0	713.5	1311.9	0.0	8728.4	-3.694
WORKERS	1756.3	2947.0	0.0	164.8	6029.5	709.9	0.0	2639.3	5893.0	0.0	20339.6	-3.200
OPTIONAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7267.0	0.0	7267.0	
TOTAL	3404.2	5984.4	0.0	200.0	8102.4	819.2	0.0	3352.8	14471.9	0.0	36335.1	
INVESTMENT												
FIRST YEAR	0.0	310.7	0.0	5532.0	0.0	0.0	7403.5	0.0	0.0	0.0	13246.1	
2ND YEAR	0.0	0.0	0.0	3724.6	0.0	0.0	3744.2	0.0	0.0	0.0	7468.8	
TOTAL	0.0	310.7	0.0	9256.5	0.0	0.0	11147.7	0.0	0.0	0.0	20714.9	
STOCK GROWTH												
OLD TECH	138.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	138.2	
NEW TECH	334.8	0.0	0.0	2857.5	5685.3	0.0	1703.1	0.0	0.0	0.0	10580.8	
TOTAL	473.0	0.0	0.0	2857.5	5685.3	0.0	1703.1	0.0	0.0	0.0	10718.9	
GOVERNMENT	0.0	0.0	0.0	64938.0	0.0	0.0	0.0	0.0	0.0	39011.0	103949.0	
FOREIGN TRADE												
EXPORTS	135.0	410.0	0.0	470.0	90.0	0.0	0.0	0.0	0.0	0.0	1105.0	
IMPORTS:												
OLD TECH	6.7	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5	
NEW TECH	5.0	1.5	0.0	554.6	41.5	0.0	0.0	0.0	0.0	0.0	604.5	
OPTIONAL	297.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	297.1	
TOTAL	310.7	6.3	0.0	554.6	41.5	0.0	0.0	0.0	0.0	0.0	913.1	
NET EXPORT	-174.7	403.7	0.0	-84.6	47.5	0.0	0.0	0.0	0.0	0.0	191.9	-20.194
FOREIGN TRADE CREDITS										-192.0		
FINAL DEMAND TOTALS												
	3732.0	5598.4	0.0	77157.6	13835.3	819.2	12850.0	3352.8	14471.9	39011.0	171009.9	
GROSS VALUE OF OUTPUT												
OLD TECH	7381.7	4879.0	525.7	0.0	0.0	2761.5	0.0	2187.3	0.0	0.0	17836.2	
NEW TECH	18935.8	4137.3	15059.2	157007.3	32444.9	10793.5	12850.9	1165.5	14471.9	39011.0	305777.8	
TOTAL	26317.5	9016.3	15595.0	157007.3	32444.9	13555.1	12850.0	3352.8	14471.9	39011.0	324614.1	
DUAL VALUES OF DISTRIBUTION CONSTRAINTS												
	-20.194	-11.122	-2.517	-3.107	-11.543	-10.431	-3.252	-17.113	-2.035	-7.333		

Table VI-26. Solution Values for the Composite Reconstruction. (Millions of Rubles)

YEAR IS 1960

RESOURCE UTILIZATION REPORT

	PRODUCING SECTORS									
	AF	AL	EP	PG	CS	FC	CO	HO	TO	GS	TOTAL
CAPITAL STOCK											
OLD TECHNOLOGY											
STOCK	3022.0	3153.1	332.2	1592.5	1473.8	7510.9	198.1	14837.1	291.6	4137.5	36719.0
UTILIZED	3022.0	3153.1	332.2	0.0	0.0	7510.9	0.0	14837.1	0.0	0.0	28855.3
PERCENT	100.0	100.0	100.0	0.0	0.0	100.0	0.0	100.0	0.0	0.0	78.6
CAPACITY CONSTRAINT											
DUAL VALUE	-27.822	-0.370	-0.594	0.000	0.000	-1.240	0.000	-2.352	0.000	0.000	
NEW TECHNOLOGY											
STOCK	11746.9	3191.5	13252.0	71012.0	5001.3	32795.5	3417.6	5632.3	4380.8	50784.8	202354.4
AVAILABLE	11371.5	2674.1	11810.5	59912.7	5956.7	30435.3	3417.6	4805.4	3734.8	43195.3	
UTILIZED	11371.5	2674.1	11810.5	35918.7	5956.7	30435.3	983.0	4806.4	3734.8	43195.3	151636.2
PERCENT	100.0	100.0	100.0	53.0	100.0	100.0	28.8	100.0	100.0	100.0	86.3
CAPACITY CONSTRAINT											
DUAL VALUE	-21.670	-1.849	-0.551	0.000	-1.311	-1.277	0.000	-3.799	-4.129	-3.374	
TERMINAL INVESTMENT CONSTRAINT											
DUAL VALUE	-1.123	-2.017	-0.771	-0.773	-0.773	-0.774	-0.770	-0.775	-0.774	-0.778	
LABOR FORCE											
OLD TECH	11654.4	1505.9	10.5	0.0	0.0	944.2	0.0	486.8	0.0	0.0	14611.9
NEW TECH	18073.6	816.3	92.3	5922.5	3632.3	1279.4	751.3	124.2	1014.5	4796.5	37513.2
TOTAL	29737.9	2322.0	103.4	5922.5	3632.3	2223.5	751.3	511.0	1014.5	4796.5	52125.0

TOTAL LABOR SUPPLY: 73994 EMPLOYED: 52125 PERCENT EMPLOYED: 70.4 DUAL VALUE: 0.000

CANT FINDSOLUTION

Appendix A Statistical Foundations

Appendix tables

Appendix A. Statistical Foundations

Dimensions and coverage of the data

Conceptually this study attempts to present its material in real terms, but its aggregate data are necessarily ruble magnitudes. As much as possible, they employ base period prices, usually in the form of "1926/27 rubles." Official Soviet statistics using "1926/27 rubles" became increasingly dubious after 1930 or so, as Professor Bergson and many others have shown. In this study, however, they are only used as measures of the base-period situation in 1928, or as indicators of expansion intentions expressed in the first FYP. Soviet prices in the late 1920s may have undervalued fixed capital relative to current output, and underpriced manufactured goods relative to primary products, but the general level only rose by two or three percent from 1926/27 to 1927/28, and the "1926/27 rubles" seem to provide an adequate set of weights for our purposes. Many targets for the terminal year of the first FYP were estimated by Gosplan, not only in terms of "1926/27 prices," but also in terms of values that would reflect substantial reductions in construction costs and production costs. These targets in "reduced cost" prices understate the intended physical change in outputs and inputs, mixing price and quantity changes in ways that would confound orderly analysis. They are therefore ignored in this study.

In forward-looking planning, ex ante prices have to be employed. One might conceive of a set of relative prices emerging as the dual to a terminal-year solution for a vast linear programming problem incorporating all intervening real structural changes in the economy, but the concept itself was not available fifty years ago, nor would a sufficiently disaggregated solution be readily obtainable even today. Application of late-year

price weights, reflecting the impact of structural change, is certainly relevant in measuring growth rates, and if this project were on a larger scale it could investigate the impact on measured structural change of late-year weights. Constrained by resources, however, and since our purpose is to investigate the Soviet economy's potential for producing a new, intended bill of goods, we can take some analytic consolation from the late Richard Moorsteen's finding that base-period weights are conceptually the most appropriate weights for aggregation.

Most of the ruble data drawn on for this study were originally in purchasers prices, including trade markups, freight charges, and excise taxes, but other evidence, especially that contained in the Materialy po balansu narodnogo khoziaistva SSSR, issued by the Chief Administration for National Accounts in October 1932, makes it possible to derive flow-table estimates in producers prices for the rows of an input-output table. The details are set forth below. As for data on capital stocks, Gosplan compiled estimates in "1925/26 prices" for the first FYP, followed by estimates in almost identical coverage in "1926/27 prices" for the 1929/30 Control Figures. The national total for October 1, 1928, was put at 70,154 million rubles in "1925/26 prices" and 69,483 million in "1926/27 prices," a difference of less than one percent. As with output, the terminal-year targets for capital stocks employed here are those assuming no change in prices, rather than those anticipating marked reductions in construction costs.

The fiscal year in use at the start of the first FYP covered a twelve-month period from October 1 through the following September 30. The base year preceding the plan period therefore ran from October 1, 1927, through

September 1928; the terminal year ended September 30, 1933. In this study, these two years are referred to as 1928 and 1933. During the plan period, planning and administration were shifted to a fiscal year coinciding with the calendar year, beginning with January 1, 1931; the "special quarter" at the end of 1930 was made the occasion for extra campaigns for over-fulfillment of plan targets. The shift does not, however, affect the computations in this project.

The capital stocks on hand and intended are set forth in the FYP by year and by sector, together with gross investment and annual depreciation estimates, for the three pre-plan years 1925/26-1927/28 and for the full plan period, 1928/29-1932/33. Following Eckaus and Parikh, I take the capital stocks on hand at the beginning of a year as the constraints on that year's activity. For base period output/capital ratios, therefore, I use active October 1, 1927 capital stocks in the denominator, and base year output levels in the numerator for each sector. For terminal-year output/capital ratios, I deduce the October 1, 1932 active stocks implied by growth toward the October 1, 1933 targets and compare them with intended terminal-year output levels. One could center the capital stocks at midyear for elegance, but the impact on computations would be negligible.

Our purpose here is to trace large flows among the major sectors of the economy, including the income and product flows of the usual national accounts, but covering also the entries in the northwest quadrant of an economy-wide input-output table. Soviet research in this direction had already led to publication of a set of national balances for 1923/24, and fragments of similar elements and computations appear in the 1929-30 Control Figures and

in the first FYP. The Soviet statistical concept of gross output is roughly similar to gross output in the input-output sense. Plan data are incomplete at various points, however, so substantial rearrangement and amplification is required in order to build the two crude tables employed in this study.

The agricultural sector here is divided into field crops and livestock products; forestry is included with field crops while fishing and hunting are included with livestock products. Until the mid-1930s, Gosplan included the construction industry, i.e., the erection of new capital plant and installation of new capital equipment, in the industrial sector, along with the industry manufacturing construction materials. For this study I have attempted to subtract out the fixed assets and current output of the construction sector to form a separate sector whose capital-forming activities play a crucial role in the model. Gosplan documents, on the other hand, devote substantial attention to electrification, and show the electric power industry separately from other industry. Given its high priority, it is thus informative to retain electric power as a separate industry. All remaining industry is divided between producer goods and consumer goods as explained below. Plan data on the communications sector are here combined with data for the transportation sector to make up a single sector. Plan data on capital stocks show very substantial amounts of urban and rural residential capital, so a housing sector clearly requires recognition. The flow of services from this capital must be crudely estimated, however, since Soviet plan accounts do not recognize this form of output. Gosplan data on assets make it possible to distinguish two other sectors, one for trade and distribution, and another for government services: education, public health, municipal services, and government administration. Output measures for these two sectors are less certain, but the available clues are utilized.

The 1928 and 1933 flow tables

Table 1 presents summary data for several main categories in gross agricultural output, illustrating the kind of coverage problem that is involved in constructing flow tables for the Soviet economy. The first three columns related to fiscal 1927/28; the fourth column to calendar 1928; and the last two columns to the terminal year of the first five-year plan. The figures are reported in "1926/27 prices," except that the fourth column figures are in 1928 current prices. A glance at the table discloses modest differences in figures that appear to represent the same item, together with several gaps. Column six shows the extent to which agricultural targets in the "optimal variant" were more ambitious than the "basic variant" targest (in column 5) for agriculture in the first FYP.

The central agricultural activities of growing field crops and producing livestock products are surrounded by several peripheral activities whose dimensions have to be deduced from inclusions and exclusions in Soviet sources. In the FYP, for example, the all-inclusive totals for columns 2, 5, and 6 appear on pp. 162-65 of Vol. I, together with a smaller figure for zemledelie ("agriculture proper"). Data for forestry appear in FYP, Vol. II, part 1, p. 372, so a residual I take to be for fishing and hunting is precipitated. For 1927/28 it checks precisely with the fishing and hunting output given in the 1928/29 control figures (Kontrol'nye tsifry nar. khoz. SSSR na 1928/29 god — hereafter KTs 28/29), p. 398. Further detail appears in KTs 28/29 at p. 476, and, as entered in column 3, in the control figures for 1929/30 (KTs 29/30), at pp. 534-35 and 422-24. These make the entries in FYP, Vol. II, part 1, pp. 334-35 more identifiable. All purport to be in 1926/27 producers' prices, and the generally small variations are not further explained. The column 4 figures are for calendar 1928 in 1928 prices, from Materialy po

Table 1. Agricultural gross output, 1927/28, 1928, and Plan 1932/33, alternative versions, in millions of rubles.

	1928/29 control figures	First Five-year Plan	1929/30 control figures	1932 balan-ces	1933 basic targets	1933 optimal targets
Field crops:						
All grains	3 739	3 731	3 551	4 449.4	5 232	5 618
Vegetables	3 751	3 032	4 596	2 842.7	4 649	5 085
Technical crops	901	911	965	1 046.6	1 619	1 854
Meadow grass	1 953	1 542	2 105	2 072.2	1 912	1 912
Forestry	1 765	1 765	1 757	1 411.3	2 596	2 596
Total field crops and forestry	(12 109)	(10 981)	(12 974)	(11 822.2)	(15 828)	(17 065)
Livestock products:						
Meat, poultry, milk	4 114	NA	4 438	4 449.2	NA	NA
Fish and game	368	368	391	323.5	580	580
Raw materials	545	NA	642	623.2	NA	NA
Growth of herds	266	546	-79	NA	1 002	1 002
Manure	244	NA	350	NA	NA	NA
Total livestock products, hunting, and fishing	(5 537)	(5 678)	(5 742)	(9 153.9	(8 050)	(8 741)
Total for agriculture, hunting, fishing, and forestry	17 646	16 659	18 716	20 976.1	23 878	25 806

balansu nar. khoz. SSSR za 1928, 1929, i 1930 g.g. -- hereafter MPB, pp. 139, 109, and 185.

The figures in Table 2 provide greater detail on the items making up the entries in Table 1. They reflect application of average annual 1926/27 prices (from KTs 29/30, pp. 581-82) to physical quantities. The 1928 quantities are drawn from MPB appendix tables, pp. 312-31 and 280-85 (for timber and firewood). The "optimal variant" targets for 1932/33 are from the FYP. The computed ruble amounts, in turn, are generally quite close to those reported for 1927/28 KTs 28/29 and KTs 29/30 if they appear there.

The compilers of MPB assembled remarkable detail on the sources and uses of all these items, showing physical amounts, ruble amounts, and quotients (average prices) for all but a few cells, with the price varying, cell by cell, across each row. I multiplied the physical quantities by the average 1926/27 producer price of each gross output instead, and summed the resulting ruble values delivered to each receiving sector in order to obtain flow-table rows for field crops (including timber and firewood) and for field crops (including timber and firewood) and for livestock products (including fish and game, but excluding growth of herds).

No such detail being available in the FYP, I applied the 1928 row structure to the 1932/33 gross output targets for each crop or product to obtain an estimate of the anticipated flows to receiving sectors. Since the intended increases of 1932/33 over 1927/28 varied from product to product -- see column 3 in Table 2 -- the composite structure of field-crop deliveries and livestock product deliveries implied by the plan targets differed somewhat from the base-period structure.

Table 2. Gross output of individual field crops and livestock products, 1928 and Plan 1933, in million of rubles at 1926/27 prices

	1928	1933	% increase
Field crops			
All grains	3 741	5 618 (a)	50
Vegetables & root crops	1 921	3 299 (b)	72
Timber and firewood	1 765	2 596 (c)	47
Meadowgrass	1 542	1 912 (a)	24
Potatoes	1 084	1 675	55
Fibers (cotton, flax, hemp)	503	981	95
Oilseeds	242	511	111
Sugarbeets	122	227	86
Hay	34	111	226
Tobacco	33	62	88
Makhorka	15	23	53
Other (fruit?)		50 (f)	
All field crops	11 002	17 065	55
Livestock products			
Meat and poultry	1 949	2 914	50
Milk and dairy products	1 823	2 846	56
Fish and game	368	580 (d)	58
Manure	350	446 (e)	27
Eggs	328	594	81
Wool	144	237	65
Small hides	164	201	23
Large hides	175	171	-2
Other		196 (f)	
All livestock products	5 301	8 185	54

Sources: For 1928, see text. FYP, II, 1, pp. 338-39 for 1933 targets, and KTs 29/30, pp. 581-82, for prices, except as noted. (a) FYP, II, 1, p. 335. (b) FYP total nongrain nontechnical minus above estimates for potatoes and hay. (c) FYP, II, 1, p. 372. (d) FYP, I, pp. 162-65. (e) 1928 figure raised in proportion to intended growth of herds. (f) Totals less enumerated items.

Summary data on utilization of the grain crop, actual in 1927/28 and intended in 1932/33, appear in a "bread-forage balance" in FYP, II, 1, page 341. The amounts shown for livestock feed are treated in this project as deliveries from fieldcrop agriculture to livestock-products agriculture, except for the feed going to horses, which is an intrasectoral flow. For the latter I have drawn on Naum Jasny, who analyzed grain crop utilization in some detail in his Socialized Agriculture of the USSR (1949), Note J, pp. 748-60, supplemented by his paper, "Soviet Grain Crops and Their Distribution," International Affairs, Oct. 1952, pp. 452-59. He shows annual feeding rates for adult horses of 464, 593, 458, and 408 kilograms per head from 1925/26 through 1928/29 on p. 753, and suggests an average for the period of "about 450 kilograms" (p. 458), evidently considering 1926/27 atypical. Multiplying 21.4 million head of working horses (FYP, II, 1, p. 38) by 458 yields 9.8 million tons of grain, 40.21% of the total used for feed in 1927/28; the same share is assumed for 1933.

In connection with actual developments after 1928, one might assume lower feeding rates under the stress of collectivization except that Jasny notes (p. 458) "...a counteracting factor is the fact that large farms generally tend to use more concentrated feed for their animals than small farms...," and his further observation (p. 755) that "...the great shortage of all kinds of draft power would have necessitated more work and more concentrated feed per work animal." Applying the same feeding rate and noting the fall in the total number of horses from 32.6 million on Jan. 1, 1929 to 14.9 million on Jan. 1, 1935, suggests a proportionate fall in grain consumed by working horses, thus releasing as much as 5.6 million tons of grain annually for human consumption.

Five-Year Plan documents provide abundant data relating to industry but, as with agriculture, many issues of definition and coverage complicate an effort to prepare unambiguous estimates for flow tables. The most detailed statistics came to Gosplan and TsUNKhU from so-called "census industry," especially those enterprises whose activities were planned by Vesenkha. There were, however, enterprises in census industry not under the supervision of Vesenkha, and there was a good deal of activity in so-called "small scale industry." Table 3 records some gross output totals from our four principal sources showing the diversity of summary data. Output figures are further complicated by a distinction between gross output and net output (literally translated as "the trade part"), which differed appreciably from source to source , product to product to product, and year to year. Finally, industry in the USSR has long been thought of as producing either producer goods (Group A) or consumer goods (Group B), a distinction associated with the contrast between "heavy industry" and "light industry." Responsible Soviet economists and statisticians readily recognized that some consumer goods were produced in heavy industrial enterprises, and that some of the products of light industry were consumed as intermediate inputs by industry, thus becoming in fact producer's goods. They found in practice that neither classification-- by type of product or by type of producer -- can be imposed and maintained without overlap, ambiguity, and compromise.

The national balances released in 1932 employed a conceptual framework providing a great deal of the structural information required for a present-day input-output table. Within this framework a substantial volume of detail is presented in appendix tables, extremely revealing for developments in 1928, 1929, 1930, and (to some extent) 1931. Table 4 shows the main categories appearing on both the sources and uses side of the annual balances;

Table 3. Gross Output of Census and Small-scale Industry, 1927/28, Alternative Reports, in millions of rubles at 1926/27 prices.

	(1) 1928/29 KTs	(2) FYP	(3) 1929/30 KTs	(4) (3) adj.	(5) 1932 Bal.
Census industry	13 833	13 382	14 131	14 115	19 245.0
Planned by VSNKh		10 909	11 067	11 067	
Other		2 973	3 064	3 048	
Small-scale industry	2 695	3 034	4 962	3 412	5 868.7
All industry	16 528	16 916	19 093	17 527	25 113.7
Excise taxes	1 505	1 396		1 402	1 463.0
Total incl. excise taxes	18 033	18 312		18 929	

Sources: KTs 1928/29, pp. 400, 402; FYP, Vol. II, pt. 2, pp. 84-85; KTs 1929/30, pp. 429, 592; MPB (1932), p. 185.

Note: The 1929/30 KTs data include flour millions, Col. 4 deducts estimates for flour-milling given in FYP, Vol. II, pt. 2, pp. 120-21.

detailed entries for component elements are placed in the same format. At the bottom of Table 4 is an indication of the adjustments decided on for use in the present study. Losses (line 12) are subtracted from both sides of the balance. Supplies on hand at the beginning of the year are subtracted from supplies on hand at the end of the year to obtain a measure of deliveries to inventory. Total deliveries of domestic production (net of losses) together with imports are then traced as going to interindustry receivers (line 8) and to the usual final demand claimants: households, government, investment, exports, and inventory. The MPB statisticians were meticulous in estimating the incidence of trade-transport markups, excise taxes, and import duties; as a result deliveries in purchasers prices can be reduced to deliveries in producers prices with fair precision. The MPB statisticians placed hunting and fishing with agriculture but placed forestry with industry; detailed data on roundwood and firewood enabled me to shift forestry over to join the field-crops part of agriculture. Following established Marxist-Leninist theory

Table 4: Summary national balance for 1928 as compiled in MPB 32, pp. 184-207, in millions of rubles at 1928 prices.

	Sources	Products of industry	Products of agriculture	Products of construction	Whole economy
1	Total supplies at beginning of year	5 882.9	5 271.7	1 056.7	12 211.3
2	Annual production at producers prices	27 162.4	20 116.0	4 239.1	51 517.5
3	Trade-transport markings	3 761.4	1 419.8	---	5 181.2
4	Excise taxes	1 463.0	---	---	1 463.0
5	Imports	750.2	202.9	---	953.1
6	Import duties	228.5	43.0	---	271.5
7	Total available at purchasers prices	39 248.4	27 053.4	5 295.8	71 597.6
	Uses				
8	Total consumed in production	16 424.7	12 117.9	---	28 542.6
9	Total consumed by population and institutions	14 094.0	7 151.8	---	21 245.8
10	Total delivered for fixed investment	1 820.5	870.7	3 677.3	6 368.5
11	Exports	491.8	307.7	---	799.5
12	Losses	74.6	204.1	---	278.7
13	Total supplies at end of year	6 342.8	6 401.2	1 618.5	14 362.5
14	Total distributed in purchasers prices	39 248.4	27 053.4	5 295.8	71 597.6
15.	Total supplies minus starting supplies (13-1)	459.9	1 129.5	561.8	2 151.2
	Total deliveries at purchasers prices (8+9+10+11+15)	33 290.9	21 577.6	4 239.1	59 107.6
	Deductions (3+4+6)	5 452.9	1 462.8	---	6 915.7
	Total deliveries at producers prices (2+5-12)	27 838.0	20 114.8	4 239.1	52 191.9

the MPB statisticians did not, however, provide much information on the output of nonmaterial economic activities; these had to be estimated in ways explained below.

After a good deal of frustrating experiment it has seemed best for present purposes to make no use of Soviet figures for net output, relying instead on the rather detailed appendix material in the 1932 MPB providing breakdowns beweeen "means of production" and "objects of consumption" as they were delivered to major sectors of the economy. Using these two categories, two rows can be developed for industry. Because of its high priority, the electric power subsector of heavy industry is here separated out from the producer goods row. At the same time it is necessary to draw as much as possible from the FYP itself for gross output figures relating to actual 1927/28 and to intended 1932/33, since they provide the most conclusive evidence on the planners' own figures and intentions. These are conveniently summarized in a table in FYP, II, 2, pp. 78-79, showing effective demand for industrial goods, in millions of rubles at purchasers prices:

	1927/28	basic variant 1932/33 targets	optimal variant 1932/33 targets
Demand for means of production:			
Agriculture and forestry	706	1 852	1 958
Industry and electrification	6 372	10 393	10 900
Transport	924	1 876	2 280
Communications	80	103	108
Trade	290	388	481
Communal economy	178	350	514
Housing construction	460	866	985
"Nonproductive" commissariats	125	341	408
Total demand for means of production	9 135	16 169	17 634
Demand for means of consumption:			
Urban population	3 062	4 474	4 866
Rural population	3 318	5 077	5 441
Collective consumption, by "nonproductive" commissariats and other pro- organizations	1 010	1 520	1 617
Total demand for means of consumption	7 390	11 0.1	11 924

Exports:			
Means of production	330	845	1 005
Means of consumption	76	159	167

The MPB appendix tabulations permit subdivision of the deliveries to agriculture and forestry into four cell values in each year, identifying the deliveries to fieldcrop agriculture and livestock agriculture of both producer goods and consumer goods (since MPB records some consumer-good deliveries not distinguished by the FYP).

The industry and electrification numbers require different treatment since MPB went considerably beyond Gosplan in estimating the interindustry deliveries that are very large and important. The MPB tabulations separate all industry into census and small-scale industry, and for each of them MPB shows their gross output of means-of-production products and means-of-consumption products. The tabulations also show the input receipts of means-of-production products by census industry and by small scale industry, as follows, in millions of rubles at 1928 prices:

		Produced	Received
	means of production	12 211.3	9 562.8
Census industry	means of consumption	7 020.6	1 376.0
	combined total	19 231.9	10 938.8
	means of production	1 115.5	977.7
Small-scale industry	means of consumption	4 667.9	536.9
	combined total	5 783.4	1 514.6

Applying the crude standard assumption that census industry used its inputs in the same proportions for producing means-of-production products as it did for producing means-of-consumption products, one obtains estimates for the flows of each input category into each output category; similar treatment yields

flows in small-scale industry as well. Adding census industry and small scale industry together yields the following deliveries:

	to producer goods	to consumer goods
From producer goods	6 261	4 280
From consumer goods	977	936

These total 12,454 million rubles, almost twice the 6,372 million Gosplan shows for 1927/28, but the added amounts appear plausible as intrasectoral flows and at least crude cell values are needed for the interindustry technology matrix. A cell value for electric power is derived below.

For transport and communications, MPB estimates provided a percent division between producer and consumer goods that is applied to the FYP figures. For the construction sector MPB estimates are used instead of the FYP figure which is limited to housing construction alone. The FYP figure for "communal economy" is accepted as applying to producer goods used in the sector supplying housing services to the urban population. For trade, the FYP figure is divided in MPB proportions. The two FYP figures for "unproductive commissariats" are taken as applying to the government services sector. The urban and rural consumption figures are subdivided in MPB proportions since here again the MPB statisticians had more thorough breakdowns. The FYP export data are accepted as given. An estimate for additions to stock is derived from year-end figures for 1926/27 and 1927/28, subdivided in MPB proportions. Finally, since all these figures are for domestic production plus imports, measured in purchasers prices including a trade-transport markup and excise taxes, they have been reduced across each row by uniform percentages derived from the detailed MPB appendix information.

Industry rows for the 1933 flow table are built on the gross output targets for producer-goods and consumer-goods production, assigned in the ways intended by Gosplan, but subdivided in the proportions uncovered for 1928 by the MPB statisticians. This approach fails to capture some of the structural change that lay within the aggregates published in the first FYP but at least it reflects the diverse growth intentions planned for combined deliveries to individual receiving sectors.

Deliveries of electric power can be deducted from the producer goods row on the basis of scattered information in the first FYP and elsehwere. The MPB study presents an electric power balance for 1928 in kilowatt-hours and in rubles (p. 267); its KWH figures conform closely to those in FYP, II, 1, p. 66, as indicated in the following tabulation:

	1928			
Receiving sector:	MPB	FYP	1933 basic	1933 optimal
Agriculture	45	35	210	(254)
Census industry	3 268	3 130	11 700	15 000
Transport and communications	111	140	400	(484)
Communal and consumption uses	1 039	815	1 870	(2 262)
Station use and transmission losses	540	930	2 820	4 000
Total	5 003	5 050	17 000	22 000

The 1933 figures in parentheses distribute the unstated optimal residual in basic-variant proportions. The deliveries to census industry can be divided into deliveries for means-of-production industry and means-of-consumption industry on the basis of detailed absolute estimates for 1927/28 in the TsUNKhU statistical handbook, Narodnoe khoz. SSR: stat. sprav. 1932, pp. 40-41. The MPB ruble data are used for 1928 and a 1928 price of 91.2 rubles per 1000 KWH is used to get 1933 ruble estimates.

Entries for the input column of the electric power sector are not readily available from plan documents, so I have applied the estimates developed by the Indian Statistical Institute for India in 1959/60, as reported by Richard S. Eckaus and Kirit S. Parikh in Planning for Growth (1968), p. 60. The principal flows involve coal, rail transport of coal, and the diagonal cell (including losses).

The first FYP lacks financial detail for a transport and communications flow-table row, but some dimensional evidence is available from other sources, especially a statistical publication issued by the transport commissariat setting forth the plan's transport aspects (though mainly for the "basic variant"). Actual and expected revenues from freight and passenger service by the several carriers are set forth in Table 5; the dominant role of the railroads is apparent.

Table 5. Transport sector revenues, 1928 and 1933, by mode, in millions of rubles

Carrier	1928 Total operating revenue	Passenger service	Freight and other
Railroads (27/28	1721.2	317.8	1403.4
State steamships (1928)	102.9	20.2	82.7
Soviet trade fleet (1928)	28.4	3.9	24.5
Caspian steamships (1928)	28.9	1.3	27.6
Sea ports (27/28)	9.0	---	9.0
Waterways 27/28)	.7	---	.7
Total, all carriers	1891.1	343.2	1547.9
	1933		
Railroads (32/33	2699.5	407.0	2292.5
State steamships (1933)	197.2	27.6	169.6
Soviet trade fleet (1933)	61.8	6.8	55.0
Caspian steamships (1933)	37.3	1.2	36.1
Sea ports (32/33)	19.7	---	19.7
Waterways (32/33)	1.1		
All transport	3016.6(a)	442.6	2574.0
All transport under "optimal variant"	3460.3	507.7	2952.6

(a) Sum of components; card 1 in source gives 3014.0.

Source: Nar. komm. putei'soob., Tsen. plan. unrav., otdel stat. i kart., Piatiletnii plan transporta na 1928/29--1932/33 g.g. (Moscow, 1929), cards 1, 49, 62, 70, 69, and 61.

The introduction to the transport commissariat plan document explains that the optimal variant of the plan "actually does not change the basic lines of the basic variant but only strengthens its several parts." Some of the major railroad bench marks are shown in their optimal-variant form, and in particular, the anticipated 1933 total operating revenue figure of 2,699.5 million rubles is raised in the optimal variant to 3,096.6 million, an increase of 14.71 percent. I have therefore applied this expansion factor to the all-transport targets to obtain "optimal variant" totals.

For both the 1928 and the 1933 flow tables, these freight revenues must be allocated to various receiving sectors along the transport and communications row. The composition of Soviet freight traffic was such that the great bulk of these charges was paid by industry on its inputs. Without seeking to compile data on ton-kilometers carried and 1926/27 rates charged for each commodity group, I draw on NKPS estimates for the percent composition of rail freight traffic in 1927/28 and in the basic variant for 1932/33 to obtain rough measures of deliveries to producer goods industry, consumer-goods industry, and urban households. The commodity groups covering coal and coke, oil, timber, ores, and iron-and-steel accounted for 48.2% of 1927/28 ton-kilometers; their share was expected to be 41.0% in 1932/33. These shares are applied to all-carrier freight revenues to yield entries for producer-goods industry outlays on the transportation of their inputs. Movement of grain and salt similarly accounted for 15.7% and 14.1% of rail ton-kilometers, and these shares are used to obtain an estimate of outlays by consumer-goods industry. The 5.6% and 4.0% of rail ton-kilometers involving firewood reflects a large scale flow mainly sent to urban households. The remaining one-third of freight traffic is not allocated under this

procedure, but parts of it went to each of the three principal recipient sectors, so fuller information might not change the breakdown drastically. A 1927/28 ruble figure for rail revenues earned by railroad administrations carrying traffic for the account of other railroads ("company freight" in U.S. rail records), is taken from A. M. IAkobi, Zheleznye dorogi SSSR v tsifrakh (1935), pp. 64-65, and raised in proportion to all freight revenue for 1932/33. By crude assumption I assign 50% of the outlays on passenger transport to urban households, 30% to rural households, and 20% to government travellers, placing these amounts in the relevant cells of the transport and communications row. The first FYP, II, 2, p. 318, puts operating revenues for the communications sector at 171.8 and 262.1 million rubles for 1928 and 1933 respectively; in the absence of any detailed evidence I assume that 40% of these charges were paid by government, 20% by urban households, 10% by rural households, and 15% each by producer goods and consumer goods industry.

The trade-and-distribution sector's contribution to economic activity, being nonmaterial, was not much noticed in the first FYP, but its role can be traced in the records. Its "net product" appears in the national income accounts summarized in FYP, Vol. I, at p. 158, where it is equated with the "trade markup" (vyruchka) and placed at 2,825 million rubles for 1928 and 5,958 for 1933. Since the services were delivered primarily in connection with manufactured goods, I have divided these amounts between peasants and workers in proportion to the outlays that each population category was expected to make on manufactured goods, drawn from the data in FYP, Vol. II, part 2, pp. 72-75.

Another category of nonmaterial output whose role deserves recognition in our input-output tables is government services. Total ruble outlays

were estimated in the first FYP as follows (in millions of rubles):

	1928	1933 targets basic variant	1933 targets optimal variant
Education	1 029.0	2 339	2 570
Health care	607.6	1 080	1 258
Social insurance	90.2	201	299
Administration and defense	1 127.4	1 460	1 485
Courts and security	100.0	127	147
Total	2 954.2	5 207	5 758

Source: FYP, Vol. II, part 2, pp. 258 and 388-89.

These services went partly to the rural and urban population (education, health care, social security), and partly to the state (administration, defense, courts, and security). Services directly to the public can be divided between rural and urban consumers on the basis of a table in MPB (p. 164) allocating "free socio-cultural services" for 1928 in 1928 prices. I have applied the same proportions to the 1933 target.

The fixed capital column in the final-demand quadrant of the 1928 and 1933 flow tables records four types of delivery. The first reflects the growth of the fixed capital stock in livestock-products agriculture, where herds of cattle, horses, camels, and bullocks, together with flocks of sheep and pigs, and even hives of bees, all made up a large and growing category of capital. The second and third involve flows of equipment from producer goods and consumer goods industry to go into the buildings and structures coming into use. The fourth reflects the gross output of the construction sector, at least the completed portion of it. Unfinished plant is delivered to the inventory column. Gross output totals for 1928 and 1933 are stated in FYP, Vol. II, part 1, pp. 452-53, for "outlays on construction of buildings and structures (excluding equipment) in millions of rubles at 1926/27 prices":

3,887.7 and 13 726.1 respectively. The MPB tabulations for 1928 give a total in 1928 prices of 4 239.1, of which 561.8 is an increase in inventory, i.e., unfinished construction. This proportion of unfinished to total construction is applied to both the 1928 and the 1933 FYP figures to obtain my flow table entries. The herd growth figure for 1928 is from MPB, p. 191. Their estimate is somewhat lower than the 1013 shown in KTs 29/30, p. 448, which is in the same format and context as the FYP figures (Vol. II, part 2, pp. 68-69) of 1181 and 1619 for 1929 and 1933. My 1933 entry enlarges the MPB 1928 estimate by the ratio 1619/1013.

In this model the housing sector is conceived as delivering a flow of services to urban and rural households, derived mainly from the very large stock of fixed capital on hand in 1928. The first FYP discusses the housing problem, concentrating on urban housing, but contains no estimates of the gross output of this nonmaterial form of production. Fragmentary data on urban household expenditures suggest outlays of 894 million rubles in 1928 and 1,541 million rubles in 1933. The 1928 outlay implies a rate of return on the existing urban housing stock of 7.17%. Applying it to the existing and intended rural housing stock yields estimates of 800 million rubles in 1928 and 1020 million rubles in 1933 for rural outlays, essentially imputed rent on owner-occupied peasant housing.

Capital stocks

The stocks of fixed capital on hand as of October 1, 1927 and October 1, 1928, together with those anticipated for October 1, 1932, were recorded with a fair amount of sectoral detail in our four basic documents. The FYP, Vol. II, part 2, pp. 66-69, gives annual estimates for 1928-1933 in 1925/26 prices. Estimates for Oct. 1, 1927 in 1925/26 prices are in KTs 28/29, pp.

426-29. After the FYP was published, KTs 29/30 presented estimates in 1926/27 prices--differing from the figures for Oct. 1, 1928, in 1925/26 prices by less than one percent--but instead of restating the Oct. 1, 1932 figures proportionately enlarged, so that output and capital would both be in 1926/27 prices, I have retained the estimates that underlay Gosplan computations in the FYP itself. The estimates for Jan. 1, 1928 in MP3 in 1928 prices suggest no significant changes but add very useful evidence on unfinished capital.

Table 6 presents the unadjusted data. In assigning these capital stocks to the ten KAPROST sectors, several subdivisions and adjustments are necessary. While livestock herds are mainly capital for the livestock products sector, horses provide draft power for the field crops sector, to which the capitalized part of irrigation and land improvement outlays is also assigned. I have arbitrarily divided the entries for economic structures 50-50 between the two sectors and assumed that 3/4 of the "dead inventory" (plows, wagons, and other agricultural equipment) relates to field crops; 1/4 to livestock products.

In rearranging the entries for industry, one must first deduct the workers' housing attached to this account, then extend the split between Group A and Group B so that it covers all planned industry, other state industry, and cooperative and private industry. It is also necessary to project the 1928 proportions back to the preceding year. Among the branches of Group A industry, Soviet statisticians included the production of building materials (bricks, cement, etc.), but no separate sector for construction, with its associated fixed capital, was recognized. I have had to assume that the capital/output ratio estimated for India in 1959-60 and reported by Eckaus & Parikh in Planning for Growth, p. 67, provides a relevant proxy for the

Table 6. Stocks of total fixed capital at the start of 1928, 1929, and 1933, by sector, in millions of rubles at 1925/26 prices.

	1 Oct. 27	1 Oct. 28	1 Oct. 32
Agriculture:			
Livestock herds	7 632	8 001	9 928
Economic structures	5 502	5 734	6 762
Dead inventory	3 089	3 280	5 424
Irrigation & land imp.	857	893	1 504
Industry:			
State industry, incl. housing	7 250		
Planned		7 940	19 044
Group A		4 550	12 981
Group B		3 298	5 330
Other		814	2 739
Housing	1 047	1 165	2 514
Coop. & private	1 008	1 059	1 420
All industry	8 258	9 813	23 203
Electrification	540	1 011	3 948
Transportation	11 248	11 653	18 263
Communications	258	286	530
Trade-warehousing	541	701	2 592
Education	1 952	1 974	3 830
Health	1 038	1 074	1 819
Administration	641	656	1 047
Communal economy	2 359	2 274	3 765
Urban housing excl. industry	11 886	11 971	13 940
Rural housing	10 399	10 833	12 635
Whole economy	66 200	70 154	109 190

capital/output ratio that prevailed in the USSR in 1928 and 1933. Multiplying the flow-table gross outputs of the construction sector by .153 yields completed capital estimates which are deducted from the Soviet figures for producer goods industry. The electrification figure for 1927 must be raised to include the generating stations placed in the communal account (assumed to have grown during 1928 at the same rate as regional and village stations); the 155 million rubles involved are deducted from the communal account.

These fixed capital stocks include the value of unfinished projects, not

separately recorded in FYP or KTs volumes. The MPB group did, however, estimate the volume of capital in process as of January 1, 1928, 1929, 1930, 1931, and 1932, for selected sectors; the figures for the first two years in 1928 prices are as follows:

	Jan. 1, 1928			Jan. 1, 1929		
	Total	Unfinished	% unfin.	Total	Unfinished	% unfi
Census industry	5 712.1	880.4	15.4129	6 436.0	1 234.5	19.181
Transport & comm.	10 750.4	130.5	1.2139	10 934.6	302.7	2.763
Urban housing	12 204.6	183.0	1.4994	12 424.6	248.5	2.000
Trade & distribution	425.9	42.2	9.9084	464.3	49.0	10.553
Social-use capital	5 454.1	144.7	2.6531	5 698.0	203.3	3.567

The percent-unfinished ratio for industry is here applied to electric power, producer-goods industry, and construction; the housing ratio is assumed to apply to rural as well as urban housing. MPB 32 being silent, I assumed that 10% of the fixed capital in both agricultural sectors and in consumer-goods industry was unfinished in both years. The adjusted figures for completed fixed capital at the beginning of 1928, 1929, and 1933 are displayed in Table 7, along with unfinished capital stocks at the beginning of each year.

Depreciation rates applicable to each sector's fixed capital can be derived from the data set forth in FYP, Vol. II, part 2, pp. 67-71 (optimal variant). I take the ratio of iznos in 1928/29 to fondy at the end of 1927/28 as a measure of depreciation applicable to old-technology capital.

and the similar ratio for 1932/33 as a measure of depreciation rates applicable to new-technology capital, without attempting an incremental computation. The sectoral rates are as follows:

	old technology	new technology	$(1-d^o)^2$	$(1-d^n)^2$
AF	8.70	7.53	.8336	.8551
AL	7.68	7.64	.8523	.8530
EP	5.24	5.17	.8979	.8993
PG	4.81	4.07	.9061	.9203
CG	5.09	4.60	.9008	.9101
TC	3.58	3.59	.9297	.9295
CO	9.94	8.59	.8111	.8356
HO	3.90	3.60	.9235	.9293
TD	4.85	5.09	.9054	.9008
GS	2.84	2.58	.9440	.9491

Table 7. Adjusted stocks of completed and unfinished capital at the start of 1928, 1929, and 1933, by sector, in millions of rubles at 1925/26 prices.

	Completed fixed capital			Unfinished capital		
	1928	1929	1933	1928	1929	1933
AF	8 267	8 813	11 913	919	980	1 324
AL	7 105	7 299	9 343	789	811	1 038
EP	600	817	3 191	109	194	757
PG	2 941	3 339	9 754	536	792	2 315
CG	2 727	3 271	5 420	303	363	602
TC	11 366	11 509	18 273	140	330	520
CO	595	714	2 100	108	169	498
HO	22 983	23 490	28 507	350	479	582
TD	487	627	2 318	54	74	274
GS	5 667	5 765	10 088	154	213	373
Whole Ec	62 738	65 749	100 907	3 462	4 405	8 283

Population and labor force

Population and labor force estimates for the 1928-1940 period can be constructed on the foundation of the 1926 Soviet population census, published in substantial detail by 1929. The potential labor force was necessarily related to the population aged 16-59; annual changes would reflect the entrance

of 16-year-olds and the exit of 60-year-olds. The first FYP reviewed many details of labor force composition, focusing especially on the urban labor force earning wages and salaries, and projecting changes in the role of the proletariat vis-a-vis the bourgeoisie. But for the KAPROST model, which allocates labor to producing sectors as part of each solution, we can confine ourselves to a measure of the potential labor force available in each year, along with parameters controlling its allocation and specifying the resulting earned incomes.

We begin, therefore, with Table 8, which shows estimates of the number of people (males plus females) reaching age 16 and reaching age 60 for each year from 1928 through 1941. In the absence of direct intercensal evidence, these projections come from reported one-year cohorts in the 1926 census, neglecting the normal mortality that would have thinned the ranks of each age group after 1926, and thus exaggerating somewhat the labor force increments hypothetically available. The unadjusted series is taken from the 1926 census as transcribed in Frank Lorimer, The Population of the Soviet Union (Geneva: League of Nations, 1946), pp. 231-32. Adjustments are required to smooth out the pronounced bulges occurring at ages 12, 45, 50, and 55 as people misreport their ages. Careful smoothing for the young males was carried out by Godfrey Baldwin of the Foreign Demographic Analysis Division of the U.S. Dept. of Commerce in his Estimates and Projections of the Population of the USSR (series P-91, No. 23, March 1973), p. 10, and I have merely applied his corrective ratios to the male-female total. The corrections for those aged 45, 50, and 55 in 1926 are cruder. The peak year is assigned a figure representing the arithmetic mean of the five years centered on it; 35% of the excess is transferred to the years immediately preceding and following the

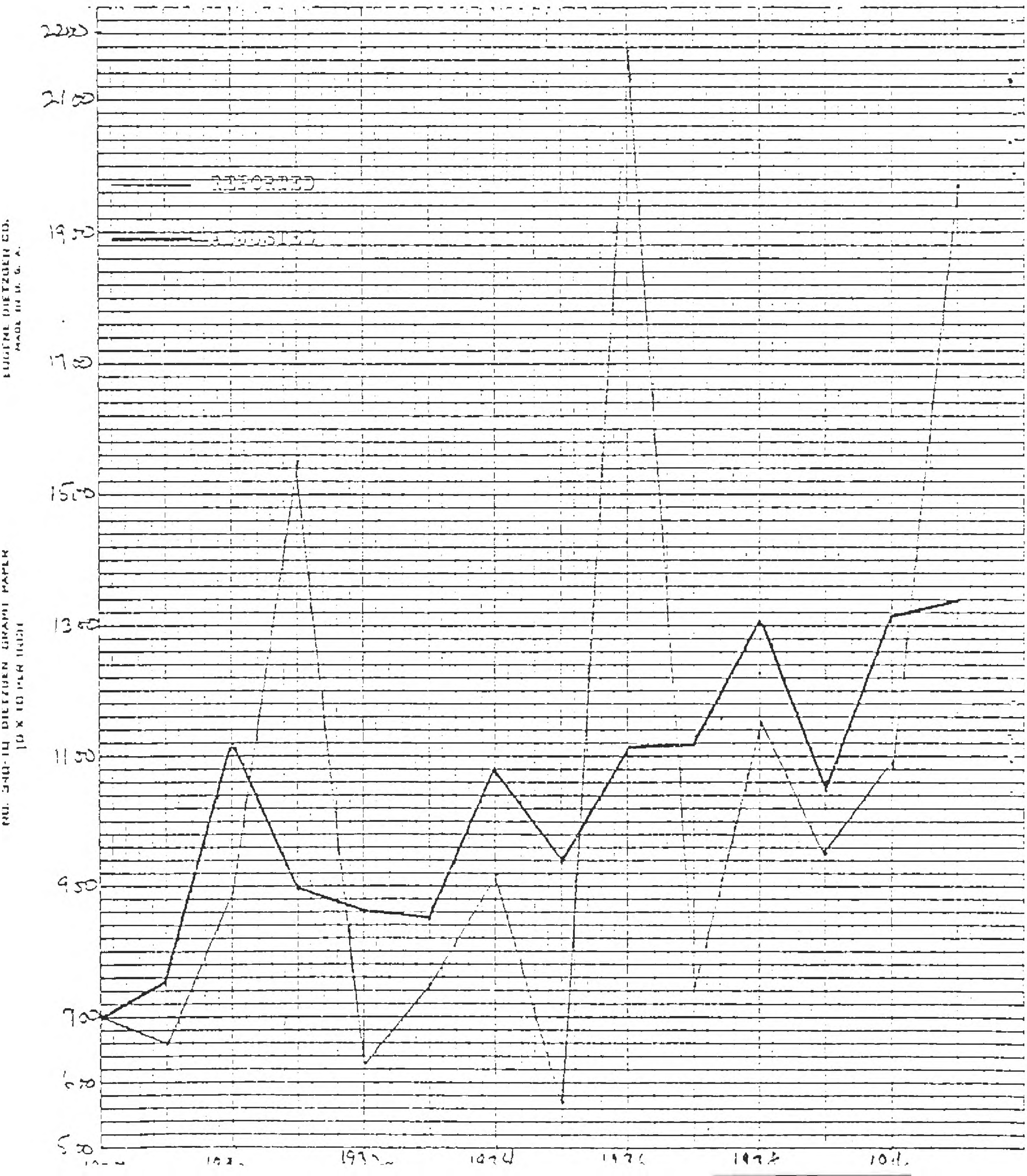
Table 8. Projected additions to and subtractions from the population aged 16-59, by year, 1928-1941, in thousands of persons.

Year of birth	Age 16 in	Unadjusted	Adjusted	Year of birth	Unadjusted	Adjusted
1912	1928	3 618	3 658	1868	699	699
13	29	3 666	3 725	69	659	757
14	30	4 237	3 700	70	890	1 118
15	21	2 669	3 303	71	1 548	895
16	32	2 901	2 976	72	630	859
1917	1933	2 322	2 803	1873	750	848
18	34	3 335	2 745	74	919	1 079
19	35	3 013	2 875	75	568	940
20	36	3 058	3 054	76	2 175	1 111
21	37	3 543	3 373	77	746	1 118
1922	1938	3 654	3 920	1878	1 147	1 307
23	39	4 543	4 533	79	952	1 046
24	40	4 415	4 415	80	1 094	1 315
25	41	4 527	4 527	81	1 969	1 338

peak year; and 15% of the excess is assigned to the adjacent years. Chart 1, p. 30 shows that the smoothed results do not suppress all variation but do display a more likely pattern than the unadjusted figures. Starting with a base-period figure for the population aged 16-59 on April 1, 1928 (as set forth in FYP, Vol. II, part 2, p. 164), we can add those entering at age 16 and subtract those reaching 60 to bring forward an annual series to 1941.

The first FYP itself contains estimates of the population aged 16-59 from April 1, 1928 through April 1, 1933, together with estimates for the engaged labor force (FYP, Vol. II, Part 2, p. 164). They imply the annual increments set forth below, appreciably smaller than those derived above in Table 8. It will be seen that Gosplan expected the ratio of engaged labor to population aged 16-59 to rise from 63.06% to 67.76% by 1933.

Chart 1. Numbers reaching age 60 in each year, 1928-1940, as derived from the 1926 census and as corrected for over-statement at ages 45, 50, and 55, in thousands of males plus females



April 1	Population aged 16-59	Annual increment	Derived increment	Engaged 000	labor force % participation
1928	82 403	2 267	2 959	51 967	63.06
29	84 670	2 349	2 968	54 189	64.00
30	87 019	1 980	2 582	56 510	64.94
31	88 999	1 424	2 408	58 633	65.88
32	90 423	1 147	2 117	60 421	66.82
1933	91 570		1 955	62 044	67.76

In order to utilize the projected series for the population aged 16-59 as extended up to 1941, but take account of the smaller increments expected by Gosplan for 1928-1933, one can compare Gosplan's engaged labor force series with my population series, obtaining a lower participation rate--rising from 63.06% in 1928 to 65.01% in 1933--and then assume that the average annual rise of .39% in the participation rate would prevail over the 1934-1940 period. The results are presented in Table 9.

Table 9. Hypothetical population aged 16-59 and engaged labor force, by year, 1928-1941, in thousands of persons

April 1	Population aged 16-59: annual increments	Population aged 16-59: total number	Engaged labor force: total number	Engaged labor force: participation rate (%)
1928	2 959	82 403	51 967	63.06
29	2 968	85 362	54 189	63.48
30	2 582	88 330	56 510	63.98
31	2 408	90 912	58 633	64.49
32	2 117	93 320	60 421	64.75
1933	1 955	95 437	62 044	65.01
34	1 666	97 392	63 694	65.40
35	1 935	99 058	65 170	65.79
36	1 943	100 993	66 837	66.18
37	2 255	102 936	68 524	66.57
1938	2 613	105 191	70 436	66.96
39	3 487	107 804	72 606	67.37
40	3 100	111 291	75 389	67.74
41	3 189	114 391	77 935	68.13

The scattered data on employment and wages in plan documents raise many problems of interpretation and coverage but suffice to provide estimates that seem adequate for present purposes. Sectoral data on annual wages and employment, actual for 1928 and intended for 1933, appear in FYP, Vol. II, part 2, especially on pages 206 and 208, but also on pp. 9, 13, 16-17, and 48. Besides the hired labor force employed in state enterprises, other nonagricultural labor earned incomes in private and cooperative enterprises or as individuals. The massive and intricate problem of estimating and projecting earnings and employment in agriculture is very sketchily dealt with in the first FYP.

The wage and employment figures assembled below are firmest for producer goods and consumer goods industry, for transport and communications, for trade and distribution, and for government services. The electric power annual wage is put at 150% of the 1928 censes-industry wage, on the basis of the relation shown for 1929 in TsUNKhU, Narkhoz 1932, p. 460; 1928 employment is taken from ibid., p. 422. Employment planned for 1933 is derived from the intended output and an assumed improvement in output-per-man of 110%, comparable to the highest expected in other high priority branches (FYP, Vol. II, part 2, p. 192). The construction sector used both hired and "other" labor; I have had to assume that the annual wage for "other" labor was the same as that in agriculture and forestry. In the absence of any attention to the labor employed in operating urban residential facilities or their annual earnings, I have placed in this sector the servants and day laborers appearing in Gosplan tabulations.

The total nonagricultural wage bill in 1928 in Table 10 comes to 9,367 rubles, not very different from the 9, 107 million rubles estimated for urban incomes by Gosplan (FYP, Vol. II, Part 2, pp. 72-73). Gosplan's estimates for workers outlays in this balance of incomes and outlays are clearly in purchasers prices, and are incomplete regarding nonhired labor. If nonhired

Table 10. Annual wage, labor force, and wage bill, by sector, 1928 and 1933, in rubles at 1926/27 prices.

Sector	Annual wage (rubles) 1928	1933	Labor force (thousands) 1928	1933	Wage bill (millions) 1928	1933
Agri., field crops	236	328	33 900	40 400	8 013	13 247
Agri., livestock products	236	328	4 700	5 700	1 109	1 862
Electric power	1 301	1 779	19	36	25	65
Producer goods industry	836	1 187	1 767	2 754	1 468	3 247
Consumer goods industry	836	1 187	3 894	4 767	3 255	5 658
Transport & communications	833	1 160	1 410	1 545	1 175	1 792
Construction	653	1 240	1 255	2 097	820	2 601
Housing	383	490	754	868	289	425
Trade and distribution	724	1 069	1 065	1 357	771	1 450
Government services	706	1 053	2 215	2 754	1 564	2 900

labor outlays were proportionate to those of hired labor, the 1928 worker consumption total would be 8, 646 million. Deducting excise taxes of 1,396 million yields a workers consumption estimate in producers prices of 7,250 million rubles, not drastically different from my flow-table compilation of 6,769 million.

The total nonagricultural wage bill in 1933 in Table 10 comes to 18,138 million rubles, substantially above my flow-table estimate of 11,997 million of workers consumption outlays in producer prices. The indicated Gosplan figure for outlays in purchasers prices is 14,145 million which, when excise taxes of 2,245 million are deducted leaves 11,900 million as an estimate with comparable coverage.

Agricultural incomes are considerably less certain. The FYP estimates of agricultural incomes and outlays (FYP, Vol. II, part 2, pp. 74-75), include the following items:

		1928		1933
Gross saving		246		880
Less: Money credit	195		417	
Statistical discrepancy	7		23	
Net saving		44		440
Taxes		545		940

I have therefore added 589 million rubles to my compiled flow-table estimate for 1928 peasant consumption to obtain an estimate for aggregate 1928 agricultural incomes, and similarly added 1,380 million to the 1933 flow-table peasant consumption total to get 1933 agricultural income. The indicated "propensities to consume" are:

		1928	1933
Peasants:	Consumption	8 533	13 729
	Income	9 122	15 109
	C/Y	.9354	.9087
Workers	Consumption	6 769	11 997
	Income	9 367	18 138
	C/Y	.7226	..6614

There is little basis in plan documents for subdividing aggregate agricultural income between field crop activities and the production of livestock products. The rural population earned incomes in many diverse activities and in fact I have had to ignore the fact that a good deal of their income came from seasonal jobs in construction or industry. The values of the two output categories combine with the structure of interindustry flows to leave far less room for value added in livestock products than in field crops. Thus if, in the absence of any clues, I assume equal per capita earnings in each branch, and follow the manpower assignment estimates in FYP, Vol. II, part 2, p. 9, the 1928 flow table will show substantial losses in livestock products. Not having firm support for any such finding, I choose instead to divide the slender nonwage value added equally between the two branches, thus precipitating the numbers in lines 1 and 2 of Table 10. The figures for number of people in each branch are not intended to convey findings growing out of independent evidence.

Foreign trade

Though planners were concerned about Soviet imports and exports, plan documents contain very little statistical analysis, presumably because prospective developments were so uncertain. Not much information is needed, however, for the KAPROST model. Exports have been estimated as part of the final-demand deliveries made by the two agricultural sectors and the two industrial sectors. The imports that provide modest supplements to domestic production can be reconstructed from scattered plan tabulations and checked in the historical statistics issued by the Ministry of Foreign Trade.

Following the approach laid down by Eckaus and Parikh in their model for India, I distinguish between the imports that are required in the production of certain sectors' gross outputs, and imports that are optional, in the sense that if sufficient export earnings or external credits are available, further imports can augment domestic production. Imports of both types are possible for field-crop agriculture, livestock-products agriculture, producer-goods industry, and consumer-goods industry; the other six sectors of the model cannot directly augment their domestic output through imports.

Imports of manufactured goods appear in a sources-and-uses table in the first FYP (Vol. II, part 2, p. 44) under the cov title, "other supply." Their place in relation to total "trade output" of manufactured goods is indicated by the following:

	1927/28	1928/29	1932/33 optimal target
Trade output of mfg. goods (millions)	13 652	15 586	26 023
"other supply"	477	429	1 255
Trade output plus other supply	14 129	16 015	27 278
Percent of "other" to sum	3.376%	2.679%	4.601%

1929 was a year of great strain in foreign trade and it will be seen that

imports fell below the 1928 level though domestic production increased. This suggests that the 1929 ratio of imports to combined imports-plus-domestic trade output indicates a minimum of required imports. Applying this ratio to 1928 shows that 378 of the 477 were required and 99 were optional. Applying the same ratio to 1933 implies that 731 of the 1255 would be required, while an increased share, namely 524, would be optional under plan intentions. These estimated amounts may be subdivided between producer goods and consumer goods on the basis of import data for 1928 in MP3, pp. 187 and 203, providing shares which are assumed to prevail in 1933 as well. We then have the following figures, in millions of rubles:

		Required	Optional	Total
	Producer goods	320	84	404
1928	Consumer goods	58	15	73
	All mfg. goods	378	99	477
	Producer goods	619	444	1063
1933	Consumer goods	112	80	192
	All mfg. goods	731	524	1255

Relating these required imports to the flow-table gross outputs, including interindustry deliveries, yields the following required-import ratios:

	Required imports	Gross output	Imports/output
1928 producer goods	320	14 676	.02180
1928 consumer goods	58	7 152	.00811
1933 producer goods	619	27 117	.02044
1933 consumer goods	112	13 405	.00836

A similar approach can be used to deduce required and optional imports of agricultural commodities, though the base-period evidence has to come from the 1929/30 Congrol Figures (KTs 29/30, pp. 566 and 424-25) and no clues are available for 1933 plan intentions. A series for "trade output, including imports, at producers prices" can be compared with another for "trade output at current prices" (with no mention of imports, and unfortunately for agricultural rather than fiscal years) to precipitate implied imports, as follows, in millions of rubles:

	1927/28	1928/29	1929/30
Including imports	5 574	6 535	6 556
Excluding imports	5 259	6 402	6 349
Gross agri. output, excluding herd growth, in current prices	17 108	21 258	20 098
Ratio of imports to gross output	.01841	.006256	.01030

The 1928 figure of 315 compares well with a figure of 331 in Min. Vnesh. Torg., Vneshnaia Torgovlia SSSR za 1928-1940 gg., p. 18. Of this total, some 273 million can be identified therein as involving the following major commodities:

Field crops:	Cotton	154	Livestock products:	Wool	61
	Vegetables & fruits	9		Large hides	39
	Grain	8		Small hides	2
		171			102

Applying these proportions to the total of 315 yields the following:

	Required	Optional	Total
1928 field crops	67	130	197
1928 livestock products	40	78	118

Relating these required imports to my flow-table gross outputs produces ratios of .00609 and .00649, which are assumed unchanged for 1933.

Appendix 3: Logic and Algebra of the Model

The KAPROST model exists in two forms. The first or structural form is a familiar set of economic relationships derived from a complete, three-quadrant input-output system, augmented by production and investment relationships. This version is easy to understand, but contains a very large number of variables and equations. In order to make the problem more manageable for computer solution, a second, reduced form of the model was created. It is derived from the first form by eliminating redundant variables and equations through substitution. This version is more difficult to understand, but much less costly to solve.

These aspects of KAPROST are described in three sections. The first section explains the terminology and symbols used in the model. The second and third sections describe structural and reduced forms respectively.

1. Terminology and Symbols

Tables 1 through 4 present concise descriptions of the various terms, variables and parameters used in the model. The input-output system upon which KAPROST is based consists of ten productive sectors, listed in Table 1. Both alphabetic abbreviations and numerical indices are used, the first because they are easy to remember, the second because they are convenient in specifying the model equations. The producing sectors may be further grouped as follows. The agricultural sectors, field crops and livestock, are contrasted with all other sectors in that our "peasant" and "worker" classification is defined in reference to employment in these sector groups. The industrial sectors consist of electric power, producer goods, consumer goods, transport and communications, and, construction. Housing, trade and distribution, and government services are the service sectors of the economy.

Table 2 relates the periods of the model to historic time. Our pre-solution base year is 1928, corresponding to period 0. The model is defined

Table 1

Sector Names, Abbreviations and Indices

NAME	Abbreviation	Index
Agriculture-Field Crops	AF	1
Agriculture-Livestock	AL	2
Electric Power	EP	3
Producer Goods	PG	4
Consumer Goods	CG	5
Transport and Communications	TC	6
Construction	CO	7
Housing	HO	8
Trade and distribution	TD	9
Government Services	GS	10

Throughout the model coding, where an arbitrary sector is to be denoted, we will use subscripts "i" and "j."

Table 2

Time Periods

Period Number	Years Covered	Comment
0	1928	Pre-Solution Base Year
1	1929 and 1930	Initial Solution Period
2	1931 and 1932	
3	1933 and 1934	Model Solution Periods
4	1935 and 1936	
5	1937 and 1938	
6	1939 and 1940	Terminal Solution Period
7	1941 and 1942	Post-Solution Periods
8	1943 and 1944	

The subscript "t" is used to denote an arbitrary period. The subscript value of "T" denotes the terminal solution period when we wish to indicate that the time horizon of the model need not be limited to 6 periods. "T+1" then indicates the first post-solution period, etc.

in terms of eight periods of two years each, of which the first six are fully solved for all economic activity. The last two are post-solution periods, but are of concern to the model in that investment decisions made in the last two solution periods will affect additions made to capital stock in these post-solution periods. Note that while our planning horizon is limited to six periods or twelve years, there is no theoretical reason why this could not be extended.

The variables used in the model are listed in Table 3 along with a brief description. Note that all variables have implicit time subscripts and technology superscripts. Further, some variables require a subscript indicating producing sector, and four of the variables are exogenously specified. A variable not specified exogenously is solved for by the linear programming algorithm.

Table 4 describes the parameter and coefficient names, and their appropriate sub-and superscripting. All of the values for these items are specified exogenously, though the manner of their derivation differs. Most parameters are derived from Soviet economic data as described in appendices A and C. Some, however, are more appropriately considered control parameters, in that their value is reset by the modeler in order to alter the characteristics of the solution. The peasant and worker average propensities to consume (α, β), the post-terminal growth parameters (γ), the social discount rate (r) and the fractions of peasant and worker consumption which must be satisfied in fixed proportions (ρ, ξ) are control rather than economically derived parameters.

2. Structural Form of the KAPROST Model

The structural form of the KAPROST model equations are given in Table 5, and our discussion below refers to the equation numbers used there.

Table 3

Glossary of Variable Names

Name	Description	Varies by Sector	Varies by Period	Exogenous Variable
A	Foreign Trade Credits (+) or Debits (-)		X	X
CP	Total Peasant Consumption		X	
CW	Total Worker Consumption		X	
D	Amortization Expenditure (Depreciation)	X	X	
E	Exports	X	X	X
F	Consumption	X	X	
G	Government Expenditures	X	X	X
H	Deliveries to Inventory	X	X	
J	Inter-Industry Uses	X	X	
K	Capital Stock	X	X	
KAPIPOT	Value of the Objective Function			
L	Labor Force in Use (Required)	X	X	
M	Imports (Required)	X	X	
N	Deliveries to Fixed Capital	X	X	
OC	Optional Consumption	X	X	
OM	Optional/Discretionary Imports	X	X	
S	Available Labor Force		X	X
X	Gross Output	X	X	
YP	Peasant Income		X	
YW	Worker Income		X	
Z	Additions to Capital Stock	X	X	

A variable which varies by sector will have its sector index as its first subscript; the time period index will always be the last subscript. Thus "X_{it}" is the gross output of sector "i" in period "t"

Note the inter-industry flow variable, J, requires two sector indices; the first for the producing sector, the second for the consuming sector.

Thus "J_{ijt}" is the delivery of output from industry "i" to industry "j" in period "t."

A superscript indicates type of technology: "O" for old, "N" for new.

Table 4

Glossary of Coefficients

Name	Description	Varied by Technology	Varied by Sector
a	Inter-Industry Technical Coefficient[1]	X	X
α	Peasant Average Propensity to Consume		
b	Output-Capital Ratio	X	X
β	Worker Average Propensity to Consume		
d	Depreciation Rate[2]		
γ	Post-Terminal Capital Stock Growth Parameter		X
k	Mastery Coefficient for Additions to Capital Stock		
λ	Output-Labor Ratio	X	X
m	Required Import Coefficient	X	X
ω	Structure of Worker Consumption		X
p	Structure of Investment Demand[3]	X	X
π	Structure of Peasant Consumption		X
r	Social Discount Rate		
ρ	Fixed-proportion fraction of peasant consumption		
s	Deliveries to Inventory	X	X
w	Wage Rate[4]		
ξ	Fixed-proportion fraction of worker consumption		

Coefficients are all exogenously specified. A coefficient which varied by technology will have a superscript to indicate the type: "O" for old, "N" for new. Sector is indicated by a subscript. Thus: "λ^N_i" is the output to labor ratio for new technology production in sector "i".

Notes:

(1) The inter-industry technical coefficients require two sector subscripts. Thus "a^O_{ij}" is, for old technology, the deliveries required from sector "i" in order to produce one unit of output in sector "j."

(2) The depreciation rate is the amount of each unit of capital which is "used up" in one year, hence is unavailable for future production.

Table 4 (cont'd.)

(3) Investment in capital follows a rigid, two-period (r year) schedule. Thus "$P^N_{1,i,j}$" is the initial period deliveries to fixed capital from sector "i" to eventually yield one unit of new capital in sector "j", and "$P^N_{2,i,j}$" is the second period deliveries.

(4) Wage rate varies by sector and by period. "W_{it}" is the wage paid labor in sector "i" in period "t."

Table 5

Structural Equations

1. Objective Function

$$(1.0)\quad KAPIPOT = \sum_{t=1}^{T} CP_t (1 + r)^{2*(T-t)} + \sum_{t=1}^{T} CW_t (1 + r)^{2*(T-t)} + \sum_{i=1}^{10} K^N_{i,T+1}$$

2. Distribution Relationships

$$(2.1)\quad J_{i,t} + N_{i,t} + E_{i,t} + G_{i,t} + F_{i,t} + H_{i,t} \leq X_{i,t} + M_{i,t}$$

$i = 1,\ldots, 10;\ t = 1,\ldots, T.$

$$(2.2)\quad J_{i,t} = \sum_{j=1}^{10} a^o_{i,j} X^o_{j,t} + \sum_{j=1}^{10} a^N_{i,j} X^N_{j,t}$$

$i = 1,\ldots, 10;\ t = 1, \ldots, T$

$$(2.3)\quad N_{i,t} = \sum_{j=1}^{10} p^N_{2,i,j} Z^N_{j,t+1} + \sum_{j=1}^{10} p^N_{1,i,j} Z^N_{j,t+2}$$

$i = 1,\ldots, 10;\ t = 1,\ldots, T.$

$$(2.4)\quad F_{i,t} = \pi_i \rho_t CP_t + \omega_i \delta_t CW_t + OC_{i,t}$$

$i = 1,\ldots, 10;\ t = 1,\ldots, T.$

$$(2.5)\quad H_{i,t} = s^0_i X^0_{i,t} + s^N_{i,t} X^N_{i,t}$$

$i = 1,\ldots, 10;\ t = 1,\ldots, T$

Table 5 (cont'd.)

$$(2.6)\quad X_{i,t} = X^{O}_{i,t} + X^{N}_{i,t}$$

$i = 1,\ldots, 10;\ t = 1,\ldots, T.$

$$(2.7)\quad M_{i,t} = m^{o}_{i} X^{o}_{i,t} + m^{N}_{i} X^{N}_{i,t} + OM_{i,t}$$

$i = 1,\ldots, 10;\ t = 1,\ldots,T.$

3. Capital Accounting Relationships

$$(3.1)\quad K^{o}_{i,t} = \overline{K}^{o}_{i,1} \quad \text{exogenous, } t = 1;$$

$$= \left(1-d^{o}_{i}\right) K^{o}_{i,t-1} \qquad t = 2,\ldots, T+1;$$

$i = 1,\ldots, 10.$

$$(3.2)\quad K^{N}_{i,t} = \overline{K}^{N}_{i,1} \quad \text{exogenous, } t = 1;$$

$$= \left(1-d^{N}_{i}\right) K^{N}_{i,t-1} + Z^{N}_{i,t} \qquad t = 2,\ldots, T+1;$$

$i = 1,\ldots, 10.$

$$(3.3)\quad D_{i,t} = d^{o}_{i,t} K^{o}_{i,t} + d^{N}_{i,t} K^{N}_{i,t}$$

$i = 1,\ldots, 10;\ t = 1,\ldots, T.$

4. Capital Productivity Relationships

$$(4.1)\quad X^{o}_{i,t} \leq b^{o}_{i} K^{o}_{i,t}$$

$i = 1,\ldots, 10;\ t = 1,\ldots, T.$

$$(4.2)\quad X^{N}_{i,t} \leq b^{N}_{i} \overline{K}^{N}_{i,1} \quad \text{exogenous, } t = 1$$

Table 5 (cont'd.)

$$\leq b^{N}_{i} \left(\gamma Z^{N}_{i,t} + (1 - d^{N}_{i}) K^{N}_{i,t-1} \right) \quad t = 2, \ldots, T;$$

$$i = 1, \ldots, 10.$$

5. Labor Productivity Relationships

$$(5.1) \quad L^{o}_{i,t} = K^{o}_{i,t} \big/ \lambda^{o}_{i}$$

$$i = 1, \ldots, t; \; t = 1, \ldots, T.$$

$$(5.2) \quad L^{N}_{i,t} = K^{N}_{i,t} \big/ \lambda^{o}_{i}$$

$$i = 1, \ldots, t; \; t = 1, \ldots, T.$$

$$(5.3) \quad \sum_{i=1}^{10} L^{o}_{i,t} + \sum_{i=1}^{10} L^{N}_{i,t} \leq S_{t} \qquad t = 1, \ldots, T.$$

6. Income-Consumption Relationship

$$(6.1) \quad YP_{t} = \sum_{i=1}^{2} W_{i,t} \left(L^{o}_{i,t} + L^{N}_{i,t} \right) \quad t = 1, \ldots, T.$$

$$(6.2) \quad YW_{t} = \sum_{i=3}^{10} W_{i,t} \left(L^{o}_{i,t} + L^{N}_{i,t} \right) \quad t = 1, \ldots, T.$$

$$(6.3) \quad CP_{t} \geq \alpha YP_{t} \qquad t = 1, \ldots, T.$$

$$(6.4) \quad CW_{t} \geq \beta YW_{t} \qquad t = 1, \ldots, T.$$

$$(6.5) \quad \rho_{t} CP_{t} + \delta_{t} CW_{t} + \sum_{i=1}^{10} OC_{i,t} = CP_{t} + CW_{t} \qquad t = 1, \ldots, T.$$

7. Balance of Payments Relationship

$$(7.1) \quad \sum_{i=1}^{10} M_{i,t} \leq \sum_{i=1}^{10} E_{i,t} + A_{t} \qquad t = 1, \ldots, T.$$

Table 5 (cont'd.)

8. Terminal Investment Requirement

$$(8.1)\quad Z^{N}_{i,T+2} \geqslant \frac{1}{T}\sum_{t=2}^{T+1} Z^{N}_{i,t} + \gamma_{i} K^{N}_{i,T+1}$$

$i = 1, \ldots, 10$

A linear programming model is an optimizing model, and so requires an objective function. Equation 1.0 presents an objective function which contains peasant and worker consumption in each year, and new technology capital stock in the first post-terminal year. The initial weighting scheme sets all weights for the year 1940 to 1, and raises the weight on consumption in earlier years by an appropriate power of the social discount rate in order to compensate for the passage of time. Clearly these basic weights are only a starting point for analysis, and in the course of simulation the coefficients on all items in the objective were changed in order to alter the characteristic of the solution. Note that the objective function captures the primary dilemma of development: the time pattern of consumption, investment and capital formation by sector.

The distribution relationships are composed of the row identity of input-output system (2.1) which limits the sum of the uses of any sector in any period to the sum of gross output and imports of that sector in that period. Equation (2.2) defines interindustry demand as a result of the gross output of each sector times the appropriate technical coefficient, for old and new technology production. Equation (2.3) shows the dependence of deliveries to fixed capital on the increments to capital stock in the next two periods. Capital requires a two period (four year) gestation period in KAPROST, with coefficients for the investment which must occur in each of the two periods in order for capital stock to increase.

Exports and government spending are exogenously specified. Equation (2.4) shows the three components of consumption: the fractions of peasant and worker consumption which must be satisfied in fixed proportions and optional consumption. Our Soviet data shows a fairly stable pattern of actual 1928 consumption and planned consumption in the first five year plan. We interpret this as representing consumer preference and require part of the consumption demand of peasants and workers to be satisfied according to the fixed proportions of

these patterns. The rest of their consumption may be optionally filled from any sector at the discretion of the solution algorithm.

Production requires some level of inventories, and in equation (2.5) deliveries to inventory are given as a fixed fraction of output. Similarly in equation (2.6) imports required for production are given as a fixed fraction of output, and total imports by sector and period are the sum of these and optional imports. Note that required inventory and import levels vary by the producing technology. Equation (2.6) indicates that gross output is the sum of that produced under old and new technology.

The capital accounting relationships record the effects on initial levels of capital stock of depreciation and new increments. Equation (3.1) an (3.2) are for old technology and new technology capital respectively, with the only difference in treatment due to our limiting investment to new technology production. Equations (3.3) calculates total depreciation.

Production is limited to a fixed multiple of capital stock as indicated in equations (4.1) and (4.2). The complexity of the relation for new technology production results from the requirement that increments to capital stock are not fully productive in the year they are made. Rather, only the fraction k of additions to capital, plus the underpreciated fraction of the previous period's capital stock are available for production. This specification is intended to represent the lower productivity which occurs while new capital is mastered by the labor forced, or worked in to use.

KAPROST uses the output-labor ratios to determine the required labor force for the output produced in each sector (equations (5.1) and (5.2), subject to the constraint of total labor force (equation (5.3)). Note that one result of this specification is that unemployment, a phenomenon never observed in the Soviet Union, is possible. Rather than interpreting unrequired workers as

unemployed, it is probably more accurate to consider them as supernumeraries in their place of work.

Income is a result of wages to required labor, as given in equations (6.1) and (6.2). Note that wages do not vary by technology. Equations (6.3) and (6.4) express, for peasants and workers, the requirement that total consumption be at least a given fraction of total income. These fractions may be viewed as average propensities to consume, or as inflation factors relating nominal income to real wage in consumption goods. In equation (6.5) we require total consumption to be satisfied in part by a fraction which must be delivered in fixed proportions of output from the producing sectors, and in part by optional consumption delivered from any sector.

Equation (7.1) requires that the foreign trade accounts for each year be in balance or in surplus.

Finally, the terminal investment requirement (equation (8.1)) forces deliveries to investment in the last solution period be high enough to allow additions to capital stock in the second post-terminal period to exceed average additions over the model solution period, plus some fraction of the final capital stock.

Note that each equation in Table 5 is simply a template. They must be expanded into separate equations either for each sector or for each time period or for every combination of sector and time period in order to completely specify the model.

3. Reduced Form of the KAPROST Model

The reduced form of the KAPROST model is presented in Table 6. It is obtained by substituting the equalities of the structural form into the inequalities so as to eliminate redundant variables. Here we indicate the substitutions made.

Table 6

Reduced Form Equations

1. Objective Function

$$(1.9)\quad KAPIPOT = \sum_{t=1}^{T} CP_t\,(1 + r)^{2*(T-1)} + \sum_{t=1}^{T} CW_t\,(1 + r)^{2*T-t} + \sum_{i=1}^{10} K^N_{i,T+1}$$

2. Distribution Relationships

$$(2.1)\quad \sum_{j=1}^{10} A^o_{i,j} K^o_{j,t} + (s^o_i - m^o_i - 1) K^o_{i,t} + \sum_{j=1}^{10} a^N_{i,j} K^N_{j,t}$$

$$+ (s^N_i - m^N_i - 1) K^N_{i,t} + \sum_{j=1}^{10} \rho^N_{2,i,j} Z^N_{j,t+1}$$

$$+ \sum_{j=1}^{10} \rho^N_{1,i,j} Z^N_{j,t+2} + \pi_i CP_t + \omega_i CW_t - OM_{i,t}$$

$$\leq -E_{i,t} - G_{i,t} \qquad i = 1,\ldots, 10;\ t = 1,\ldots, T.$$

3. Capital Accounting Relationships

$$(3.1)\quad K^N_{i,t} = \overline{K^N_{i,1}} \quad \text{exogenous } T = 1;$$

$$K^N_{i,t} - Z^N_{i,t} - (1 - d^N_i)\, K^N_{i,t-1} = 0 \quad t = 2,\ldots, T + 1;$$

$$i = 1,\ldots, 10.$$

$$(3.2)\quad Z^N_{i,t} = \overline{Z^N_{i,2}} \quad \text{exogenous, } t = 2;$$

$$i = 1,\ldots, 10.$$

4. Capital Productivity Relationship

$$(4.1)\quad X^{o}_{i,t} \Big/ b^{o}_{i} \leq (1-d^{o}_{i})^{t-1}\, \bar{K}^{o}_{i,1}$$

$i = 1,\ldots, 10;\ t = 1,\ldots, T.$

$$(4.2)\quad X^{N}_{i,t} \Big/ b^{N}_{i} - K^{N}_{i,t} \leq 0 \qquad t = 1;$$

$$X^{N}_{i,t} \Big/ b^{N}_{i} - K^{N}_{i,t} - (1 - d^{N}_{i})\, K^{N}_{i,t-1} \leq 0 \qquad t = 2,\ldots, T;$$

$i = 1,\ldots, 10.$

5. Labor Supply Constraint

$$(5.1)\quad \sum_{i=1}^{10} X^{o}_{i,t} \Big/ \lambda^{o}_{i} + \sum_{i=1}^{10} X^{N}_{i,t} \Big/ \lambda^{N}_{i} \leq S_{t}$$

$t = 1,\ldots, 10.$

6. Income-Consumption Relationships

$$(6.1)\quad \sum_{i=1}^{2} w_{i,t} \left(X^{o}_{i,t} \Big/ \lambda^{o}_{i} + X^{N}_{i,t} \Big/ \lambda^{N}_{i}\right) - CP_{t} \Big/ \alpha \leq 0$$

$t = 1,\ldots, T.$

$$(6.2)\quad \sum_{i=3}^{10} w_{i,t} \left(X^{o}_{i,t} \Big/ \lambda^{o}_{i} + X^{N}_{i,t} \Big/ \lambda^{N}_{i}\right) - CW_{t} \Big/ \beta \leq 0$$

$t = 1,\ldots, T.$

$$(6.3)\quad (\rho_{t}-1)\, CP_{t} + (\delta_{t}-1)\, CW_{t} + \sum_{i=1}^{10} OC_{i,t} = 0$$

7. Balance of Payments Constraint

$$(7.1) \quad \sum_{i=1}^{10} m_i^o X_{i,t}^o + \sum_{i=1}^{10} m_i^N X_{i,t}^N + \sum_{i=1}^{10} OM_{i,t}$$

$$\leq \sum_{i=1}^{10} E_{i,t} + A_t$$

$i = 1, \ldots, 10; \; t = 1, \ldots, T.$

8. Terminal Investment Requirement

$$(8.1) \quad \frac{1}{T} \sum_{t=2}^{T+1} Z_{i,t}^N + \gamma_i K_{i,T+1}^N - Z_{i,T+2}^N \leqslant 0$$

$i = 1, \ldots, 10$

The objective function, equation (1.0) remains unchanged. The new distribution relationship (2.1) is obtained by substituting the definitions of each of the components of the input-output table row constraint into that constraint, grouping common factors, and isolating all exogenous variables on the right hand side. This last step normalizes the form of the problem for the linear programming solution algorithm, and is done for all of the equations below.

The capital accounting relationships (equations (3.1) and (3.2) repeat the time progress of new technology capital as it appears in Table 5, making explicit the exogenous setting of the initial period new technology capital stock, and second period additions to new technology capital stock.

Accounting relationships for old technology capital stock may be disposed of; no investment in old technology capital is permitted, the exogenously specified initial value simply depreciates so that the stock for each year is effectively exogenous. This is most evident in the productivity relationship for old technology capital (equation (4.1)) where output from old technology is limited by the remainder of the initial stock after the appropriate number of years of depreciation. The relation for new technology in equation (4.2), notes the effect of the mastering requirement for additions to capital. Note that all variables in equations (4.2) appear on the left hand side as they are all solved for by the model.

The labor supply constraint given in equation (5.1) is obtained by substituting output divided by the output to labor ratio for labor. This substitution is also made in the income-consumption relationships (6.1) and (6.2) to calculate income and then relate it to consumption by the average propensities to consume. The requirement that total consumption be properly divided between a part received in fixed proportions and an optional portion is normalized in equation (6.3).

The balance of payments constraint in equation (7.1) shows the substitution of the definition of required imports into the structural form in Table 5. The terminal investment constraint (equation (8.1)) has simply been normalized.

As with the structural form equations in Table 5, the reduced form equations in Table 6 are only templates. They must be expanded for all appropriate sectors and time periods in order to yield a complete linear programming problem.

Appendix C: Data as Modified for Use by the KAPROST Model

The data estimates from Soviet and other sources presented in Appendix A need to be reformulated in order to correspond with the KAPROST model described in appendix B. These calculations, the motivating assumptions, and the data used are described here. Note that this appendix presents the data values which correspond exactly to the problem free solution. While most of these values also underlie the historic simulations, the reader should be aware of the distinction. The alternatives used for specific historic simulations are described in the body of the report with the simulation results.

1, Exports

Soviet sources provide historic export levels for 1928, and those forecast for 1933 by the first five year plan. The problem free solution is assumed to provide these forecast amounts, and for years between 1928 and 1933, and after 1933, amounts given by linear interpolation and extrapolation. Table 1 gives the yearly values so obtained. As the KAPROST time periods are two years each, these values are summed appropriately to yield the exports for each of the six solution periods of the model (Table 2). Note that only the agricultural, (both field crops and livestock), producer goods, and consumer goods sectors participate in foreign trade.

2. Government Expenditures

The development of government expenditures is affected by our use of a government services producing sector, which delivers output only to the government. Our intention in doing this was to have all normal government expenditures reflected in demand for the output of the government services sector, which required interindustry deliveries from other producing sectors, and associated that output with requirements for labor and capital stock. This provides,

Table 1

Exports (millions of rubles)

Industry

Year	AF	AL	PG	CG
1928	76	230	263	50
1929	84.4	258.8	370.6	62
1930	92.8	287.6	478.2	74
1931	101.2	316.4	585.8	86
1932	109.6	345.2	693.4	98
1933	118	374	801	110
1934	126.4	402.8	908.6	122
1935	134.8	431.6	1016.2	134
1936	143.2	460.4	1123.3	146
1937	151.6	489.2	1231.4	158
1938	160.0	518	1339	170
1939	168.4	546.8	1446.6	182
1940	176.8	575.6	1554.2	194

The 1928 values are actual exports; the 1933 values are those projected by the first five year plan. All others are the result of linear interpolation or extrapolation from the 1928 and 1933 figures.

AF: Agriculture, Field Crops

AL: Agriculture, Livestock

PG: Producer Goods

CG: Consumer Goods

Table 2

Exports by KAPROST Period
(millions of rubles)

Period	Industry AF	AL	PG	CG
1929 and 1930	177.2	546.4	843.8	136
1931 and 1932	210.8	661.6	1279.2	184
1933 and 1934	244.4	776.8	1709.6	232
1935 and 1936	278.0	892.0	2140.0	280
1937 and 1938	311.6	1007.2	2570.4	328
1939 and 1940	345.2	1122.4	3000.8	376

Values reflect two year totals from Table 1.

AF: Agriculture, Field Crops

AL: Agriculture, Livestock

PG: Producer Goods

CG: Consumer Goods

These numbers provide values for the variable "E" in KAPROST for sectors 1, 2, 4 and 5. Exports of all other sectors are zero.

again for normal government activity, a neat way of combining deliveries from other sectors, labor force and productive capital stock, rather than associate these with a final demand category directly. For other than normal scenarios, e.g. rearmament, government demand for producers goods can be specified directly, as tanks, planes, ships, etc., are produced by this sector yet do not enter into capital stock, but are considered to be consumed. However, the labor force, barracks, and common needs of soldiers can be provided for by increasing government expenditure on the output of government services, as this increases demands on all these items in proportion, plus forcing additional wage payments and consumption demands to round out the non-heavy goods requirements of the military.

For the problem free solution we again took actual 1928 and projected 1933 government expenditures and obtained values for intervening and succeeding years by linear interpolation and extrapolation. These were summed over two year intervals to obtain the G_{10} variable in KAPROST. Direct government expenditures on the output of all other sectors is zero. These results are presented in table 3.

3. Labor Supply

Yearly labor force statistics must be converted to values appropriate to KAPROST's two-year periods. This is done by taking the average labor force over the two years, and is presented in table 4.

4. Initial Levels of Capital Stock

The basic data for capital stock consist of actual 1928 and 1929 levels, plus an indication of additions to capital stock based on projects in progress in 1928. These last provide direct estimates for Z_2^N, additions to new technology capital in the second period, as given in table 5. We must therefore

disentangle the 1928 and 1929 stock figures to provide estimates of initial period capital stock of both technologies.

Our basic assumption is that all capital stock in 1928 is of the old technology, and no additions are made to it so that the only process affecting it is depreciation. Hence for each sector, the initial period stock of old technology capital is equal to the 1928 stock of capital minus depreciation. The initial period stock of new technology capital is the difference between the total 1929 stock and the calculated initial stock of old technology capital. These calculations are reproduced in table 6.

Table 3

Government Expenditures on Government Services
(in millions of rubles)

Year	G_{10} by Year	Period	G_{10}
1928	2954.0		
1929	3554.8		
1930	4155.6	1929 and 1930	7710.4
1931	4756.2		
1932	5357.2	1931 and 1932	10113.6
1933	5958.0		
1934	6558.8	1933 and 1934	12516.8
1935	7159.6		
1936	7760.4	1935 and 1936	14920.0
1937	8361.2		
1938	8962.0	1937 and 1938	17323.2
1939	9562.8		
1940	10163.6	1939 and 1940	19726.4

G_{10} is the government expenditure on the output of sector 10, government services. Direct government expenditure on the output of all other sectors is zero (though indirectly, the production of G_{10} requires output from several sectors).

Table 4

Labor Supply (in thousands)

Year	Labor Supply	Period	Labor Supply
1928	51967		
1929	54189		
1930	56510	1929 and 1930	55350
1931	58633		
1932	60421	1931 and 1932	59527
1933	62044		
1934	63694	1933 and 1934	62869
1935	65170		
1936	66837	1935 and 1936	66004
1937	68524		
1938	70436	1937 and 1938	69430
1939	72606		
1940	75389	1939 and 1940	73998

The period labor supply is the average of the yearly labor supplies in that period.

The last column data provide values for the variable S in KAPROST.

Table 5

Additions to New Technology Capital Stock in Period 2

(millions of rubles)

Sector	$Z^N_{i,2}$
AF	315
AL	1140
EP	194
PG	1308
CG	697
TC	331
CO	159
HO	479
TD	74
GS	213

Table 6

Initial Period Stocks of Capital
(millions of rubles)

Sector	(1) 1928 Capital Stock	(2) Depreciation Rate	(3) Initial Period Old Technology Capital Stock	(4) 1929 Capital Stock	(5) Initial Period New Technology Capital Stock
AF	8224	.087	7509	8488	979
AL	7594	.0768	7011	7965	954
EP	600	.0524	569	817	248
PG	3017	.0517	2861	3385	524
CG	2618	.0509	2485	2937	452
TC	11366	.0358	10959	11608	649
CO	595	.0994	536	667	131
HO	22982	.039	22086	23490	1404
TD	487	.0485	463	627	164
GS	5680	.0284	5519	5765	246

Column 1 and 4 are historic values

Column 3 = (1-Column 2) * Column 1

Column 5 = Column 4 - Column 3

Column 3 provides the exogenous values for $K^O_{i,1}$.

Column 5 provides the exogenous values for $K^N_{i,1}$

5. Depreciation Coefficients

The one-year depreciation rates obtained from Soviet data need to be converted to the two-year model periods. As the depreciation rate gives the proportion of each unit of capital used up in one year, one minus this rate is the proportion remaining after one year. The square of the proportion remaining after one year is the proportion remaining after two, and the difference between this and one the two-year depreciation rate. These calculations are repeated in Table 7.

6. Fixed Proportion Structure of Consumption

The sector proportions in which peasants and workers would choose to consume, given the opportunity, are based on actual 1928 consumption and planned 1933 consumption. As these proportions did not change significantly over the five years, the consumption-weighted averages of the two observations were used. Table 8 presents these calculations.

7. Wages

The actual 1928 wages and planned 1933 wages by sector are used to linearly interpolate and extrapolate values for the remaining years (Table 9). These values are summed over two-year intervals to provide the sector wages for KAPROST (Table 10).

8. Investment Structure

The time pattern of deliveries from capital-goods producing sectors to investment demand in order to eventually make a new unit of capital available to a given sector is a combination of two sets of coefficients. Table 11 lists, for each sector, the proportions of Livestock, Producers Goods and Construction which go into one ruble of capital stock. It is then assumed that capital is produced over two, two-year periods, with .2398 of the deliveries occurring

Table 7

Depreciation Rate Calculations

Sector	(1) One Year Depreciation Rate	(2) Remainder After One Year	(3) Remainder After Two Years	(4) Two Year Depreciation Rate
Old Technology:				
AF	.0870	.9130	.83357	.16643
AL	.0768	.9232	.85230	.14770
EP	.0524	.9476	.89795	.10205
PG	.0517	.9483	.89927	.10073
CG	.0509	.9491	.90079	.09921
TC	.0358	.9642	.92968	.07032
CO	.0994	.9006	.81108	.18892
HO	.0390	.9610	.92352	.07648
TD	.0485	.9515	.90535	.09465
GS	.0284	.9716	.94401	.05599
New Technology:				
AF	.0753	.9247	.85507	.14493
AL	.0764	.9236	.85304	.14696
EP	.0517	.9483	.89927	.10073
PG	.0447	.9553	.91260	.08740
CG	.0460	.9540	.91012	.08988
TC	.0359	.9641	.92949	.07051
CO	.0859	.9141	.83558	.16442
HO	.0360	.9640	.92930	.07070
TD	.0509	.9491	.90079	.09921
GS	.0258	.9742	.94907	.05093

Note:

(1): from Appendix A
(2) = 1.0 - (1)
(3) = $(2)^2$
(4) = 1.0 - (3)

The data in (4) provides the values for d^O and d^N in KAPROST.

Table 8

Fixed Consumption Structure

	(1) 1928 Consumption	(2) 1928 Shares	(3) 1933 Consumption	(4) 1933 Shares	(5) Total Consumption	(6) Average Shares
Peasants						
AF	1400	.16407	2293	.16702	3693	.16589
AL	2995	.35099	4752	.34613	7747	.34799
EP	--	--	--	--	--	--
PG	34	.00398	56	.00408	90	.00404
CG	2003	.23474	3284	.23920	5287	.23749
TC	120	.01406	159	.01158	279	.01253
CO	--	--	--	--	--	--
HO	800	.09375	1020	.07430	1820	.08175
TD	1181	.13840	2165	.15770	3346	.15030
GS	--	--	--	--	--	--
Total	8533	1.00000	13729	1.00000	22262	1.00000
Workers						
AF	686	.10134	1119	.09327	1805	.09618
AL	1051	.15527	1668	.13903	2719	.14489
EP	--	--	--	--	--	--
PG	59	.00872	93	.00775	152	.00810
CG	2149	.31748	3414	.28457	5563	.29644
TC	286	.04225	369	.03076	655	.03490
CO	--	--	--	--	--	--
HO	894	.13207	1541	.12845	2435	.12976
TD	1644	.24287	3793	.31616	5437	.28973
GS	--	--	--	--	--	--
Total	6769	1.00000	11997	1.00000	18766	1.00000

Note:

(1) from Soviet 1928 data
(2) (1) divided by column total
(3) from First Five Year Plan
(4) (3) divided by column total
(5) = (1) + (3)
(6) (5) divided by column total.

All calculations performed separately for Peasants and Workers. Column 6 yields values for π and ω in KAPROST.

All flows in millions of rubles.

Table 9

Wages

Sector	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940
AF	223	240.6	258.2	275.8	293.4	311	328.6	346.2	363.8	381.4	399	416.6	434.2
AL	223	240.6	258.2	275.8	293.4	311	328.6	346.2	363.8	381.4	399	416.6	434.2
EP	1301	1396.6	1492.2	1587.8	1683.4	1779	1874.6	1970.2	2065.8	2161.4	2257	2352.6	2448.2
PG	836	906.2	976.4	1046.6	1116.8	1187	1257.2	1327.4	1397.6	1467.8	1538	1608.2	1678.4
CG	836	906.2	976.4	1046.6	1116.8	1187	1257.2	1327.4	1397.6	1467.8	1538	1608.2	1678.4
TC	833	898.4	963.8	1029.2	1094.6	1160	1225.4	1290.8	1356.2	1421.6	1487	1552.4	1617.8
CO	653	770.4	887.8	1005.2	1122.6	1240	1357.4	1474.8	1592.2	1709.6	1827	1944.4	2061.8
HO	383	404.4	425.8	447.2	468.6	490	511.4	532.8	554.2	575.6	597	618.4	639.8
TD	724	793	862	931	1000	1069	1138	1207	1276	1345	1414	1483	1552
GS	706	775.4	844.8	914.2	983.6	1053	1122.4	1191.8	1261.2	1330.6	1400	1469.4	1538.8

Note: 1928 values are actual wages by sector.

1933 values are planned wages by sector

All other years are obtained by linear interpolation or extrapolation.

All numbers in rubles.

Table 10

Two-Year Wage Rates

Period

Sector	(1) 1929-1930	(2) 1931-1932	(3) 1933-1934	(4) 1935-1936	(5) 1937-1938	(6) 1939-1940
AF	498.8	569.2	639.6	710	780.4	850.8
AL	498.8	569.2	639.6	710	780.4	850.8
EP	2888.8	3271.2	3653.6	4036	4418.4	4800.8
PG	1882.6	2163.4	2444.2	2725	3005.8	3286.6
CG	1882.6	2163.4	2444.2	2725	3005.8	3286.6
TC	1862.2	2123.8	2385.4	2647	2908.6	3170.2
CO	1658.2	2127.8	2597.4	3067	3536.6	4006.2
HO	830.2	915.8	1001.4	1087	1172.6	1258.2
TD	1655	1931	2207	2483	2759	3035
GS	1620.2	1897.8	2175.4	2453.	2730.6	3008.2

Note: Two-year sums from values in Table 9.

All values in rubles.

in the first of the two periods, and .7602 in the second. Table 12 shows the P_1 and P_2 matrices which result from applying the time factors to the proportional structure given in Table 11.

9. Parameters Which Vary by Technology:

Interindustry Technical Coefficients, Required Import Ratios, Inventory Ratios, Output-Labor and Output-Capital Ratios.

Production by the two technologies available in KAPROST is completely described by the interindustry technical coefficients, required import ratios, inventory ratios, output-labor ratios and output-capital ratios. These numbers are calculated incrementally from actual 1928 flow values and planned 1933 flow values. That is, we assume that all 1928 activity is due solely to old technology production. After 1928 all investment is in new technology, so old technology capital only depreciates and never increases. Hence, by subtracting depreciated 1928 activity from planned 1933 activity we have as the remainder flows attributable solely to new technology, allowing us to calculate parameter values for new technology. Each parameter is described in turn.

a) Interindustry Technical Coefficients

Table (13a) lists the interindustry flows for 1928, and (13b) the old technology coefficients obtained by dividing entries in each column by the gross value of output of that sector. If we use the old technology one-year depreciation coefficients for each sector from Table 7, and apply them over the five years (1928 to 1933) to the 1928 gross value of output we obtain the 1933 flows which can be attributed to old technology (Table 13c). Table 13d gives the planned, 1933 interindustry flows. Table 13e gives the 1933 new technology flows obtained by subtracting table 13c from 13d. The calculation of the new technology coefficients is performed by dividing each column of table 13e by the gross value of output of that column's sector. This result

Table 11

Investment Structure of Capital

Sector Receiving Capital	Capital Goods Producing Sector AL	PG	CO
AF	.1854	.5645	.2501
AL	.6562	.1186	.2252
EP	-----	.6676	.3324
PG	-----	.4987	.5013
CG	-----	.4987	.5013
TC	-----	.4477	.5523
CO	-----	.7390	.2610
HO	-----	.3518	.6842
TD	-----	.4786	.5214
GS	-----	.1052	.8948

Note: Each entry indicates the ruble value of deliveries from a capital goods producing sector to investment demand to produce one ruble of capital in the sector receiving new capital.

Table 12

Time Structure of Capital Production

Sector Receiving Capital	(1) First Period — Capital Producing Sector			(2) Second Period — Capital Producing Sector		
	AL	PG	CO	AL	PG	CO
AF	.0445	.1354	.0600	.1409	.4291	.1901
AL	.1574	.0284	.0540	.4988	.0902	.1712
EP	——	.1601	.0797	——	.5075	.2527
PG	——	.1196	.1202	——	.3791	.3811
CG	——	.1196	.1202	——	.3791	.3811
TC	——	.1074	.1324	——	.3403	.4199
CO	——	.1772	.0626	——	.5618	.1984
HO	——	.0757	.1641	——	.2401	.5201
TD	——	.1148	.1250	——	.3638	.3964
GS	——	.0252	.2146	——	.0800	.6802

Note: (1) = Table 11 x 0.2398

(2) = Table 11 x 0.7602

Ruble value of deliveries to investment to produce one unit of capital available at the beginning of the third period.

Table 13a

1928 Interindustry Flows

Receiving Sectors

Producing Sector	AF	AL	EP	PG	CG	TC	CO	HO	TD	GS
AF	1541	2853	--	424	2944	97	718	--	--	57
AL	350	125	--	--	510	--	--	--	--	40
EP	--	5	63	177	108	17	--	--	--	196
PG	145	96	86	5346	3777	650	2119	142	186	100
CG	191	133	--	746	714	152	11	--	46	672
TC	--	--	64	981	358	116	--	--	--	137
CO	--	--	--	--	--	--	--	--	--	--
HO	--	--	--	--	--	--	--	--	--	--
TD	--	--	--	--	--	--	--	--	--	--
GS	--	--	--	--	--	--	--	--	--	--
Interindustry Total	2227	3212	213	7674	8411	1032	2848	142	232	1202
Gross Value of Output	11002	6172	566	14674	7152	2062	3888	1694	2825	2954

Note: All values in millions of rubles

Table 13b

Old Technology Coefficients

Receiving Sectors

Producing Sectors	AF	AL	EP	PG	CG	TC	CO	HO	TD	GS
AF	.14007	.46225	--	.02889	.41163	.04704	.18467	--	--	.01930
AL	.03181.	.02025	--	--	.07131	--	--	--	--	.01354
EP	--	.00081	.11131	.01206	.01510	.00824	--	--	--	.06635
PG	.01318	.01555	.15194	.36432	.52810	.31523	.54501	.08383	.06584	.03385
CG	.01736	.02155	--	.05084	.09983	.07371	.00283	--	.01623	.22749
TC	--	--	.11307	.06635	.05006	.05626	--	--	--	.04638
CO	--	--	--	--	--	--	--	--	--	--
HO	--	--	--	--	--	--	--	--	--	--
TD	--	--	--	--	--	--	--	--	--	--
GS	--	--	--	--	--	--	--	--	--	--

Note: Obtained from table 13a by dividing each column by its gross value of output.

Provides a^0 values in KAPROST.

Table 13c

Old Technology Flows in 1933

Receiving Sectors

Producing Sector	AF	AL	EP	PG	CG	TC	CO	HO	TD	GS
AF	978	1913	——	325	2267	81	425	——	——	49
AL	222	84	——	——	393	——	——	——	——	35
EP	——	3	48	136	83	14	——	——	——	170
PG	92	64	66	4100	2909	542	1255	116	145	87
CG	121	89	——	572	550	127	7	——	36	582
TC	——	——	49	752	276	97	——	——	——	119
CO	——	——	——	——	——	——	——	——	——	——
HO	——	——	——	——	——	——	——	——	——	——
TD	——	——	——	——	——	——	——	——	——	——
GS	——	——	——	——	——	——	——	——	——	——
Interindustry Total	1413	2154	163	5885	6478	861	1687	116	181	1042
Gross Value of Output	6980	4139	432	11253	5508	1718	2303	1388	2203	255

Note: Obtained by depreciating table 13a over five years. Rounded to nearest unit. Values in millions of rubles.

Table 13d

1933 Interindustry Flows

Receiving Sectors

Producing Sectors	AF	AL	EP	PG	CG	TC	CO	HO	TD	GS
AF	2430	4130	--	626	4747	144	1059	--	--	90
AL	457	202	--	--	670	--	--	--	--	62
EP	--	39	269	1038	330	58	--	--	--	545
PG	401	266	343	8788	6461	1547	5438	492	308	326
CG	529	368	--	1276	1222	361	24	--	77	1076
TC	--	--	254	1576	535	193	--	--	--	193
CO	--	--	--	--	--	--	--	--	--	--
HO	--	--	--	--	--	--	--	--	--	--
TD	--	--	--	--	--	--	--	--	--	--
GS	--	--	--	--	--	--	--	--	--	--
Interindustry Total	3817	5005	866	13304	13965	2303	5621	492	385	2292
Gross Value of Output	17065	9577	2279	27117	13405	3279	13726	2561	5953	5958

Note: Values in millions of rubles.

Table 13e

New Technology Flows in 1933

Receiving Sectors

Producing Sector	AF	AL	EP	PG	CG	TC	CO	HO	TD	GS
AF	1452	2217	----	301	2480	63	634	----	----	41
AL	235	118	----	----	277	----	----	----	----	27
EP	----	36	221	902	247	44	----	----	----	375
PG	309	202	277	4688	3552	1005	3283	376	163	239
CG	408	279	----	704	672	234	18	----	41	494
TC	----	----	205	824	259	96	----	----	----	74
CO	----	----	----	----	----	----	----	----	----	----
HO	----	----	----	----	----	----	----	----	----	----
TD	----	----	----	----	----	----	----	----	----	----
GS	----	----	----	----	----	----	----	----	----	----
Interindustry Total	2404	2851	703	7419	7487	1442	3935	376	204	1250
Gross Value of Output	10086	5438	1847	15864	7897	1561	11423	1173	3755	3400

Note: (13e) = (13d) - (13c)

Values in millions of rubles.

is presented as table 13E.

b) Required Import Ratios

Table 14 lists the incremental calculations to obtain the required import ratios for old and new technology production.

c) Inventory Ratios

Table 15 lists the incremental calculations to obtain the inventory ratios for old and new technology production.

d) Output-Labor Ratios

The old technology output-labor ratios are obtained by dividing 1928 gross values of output by sector labor force. This is multiplied by two to obtain productivity over the two-year KAPROST period. 1933 old technology labor force equals 1933 old technology gross value of output multiplied by the one-year old technology output-labor ratios. This is subtracted from total 1933 labor force. We use this as the divisor for 1933 new technology gross value of output to obtain new technology output-labor ratios. Again, multiplication by two adapts the data to the two-year period of KAPROST. See Table 16.

e) Output-Capital Ratios

Table 17 shows the calculation of old and new technology output-capital ratios. As this exactly parallels the calculation of the output-labor ratios discussed above, no further comment is warranted.

Table 13f

New Technology Coefficients

Receiving Sectors

Producing Sectors	AF	AL	EP	PG	CG	TC	CO	HO	TD	GS
AF	.14398	.40769	--	.01897	.31402	.04050	.05547	--	--	.01194
AL	.02330	.02174	—	—	.03510	--	--	--	--	.00806
EP	--	.00655	.11963	.05688	.03125	.02807	---	--	--	.11037
PG	.03064	.03707	.15018	.29552	.44983	.64418	.28737	.32034	.04338	.07041
CG	.04043	.05127	--	.04437	.08511	.15013	.00153	--	.01095	.14531
TC	--	--	.11108	.05192	.03284	.06171	--	--	--	.02188
CO	--	--	--	--	--	--	--	--	--	--
HO	--	--	--	--	--	--	--	--	--	--
TD	--	--	--	--	--	--	--	--	--	--
GS	--	--	--	--	--	--	--	--	--	--

Note: Obtained from table 13e by dividing each column by its gross value of output. Provides a^N values in KAPROST.

Table 14

Required Import Ratios

ector	(1) 1928 Required Imports	(2) Old Technology Required Import Ratio	(3) 1933 Old Technology Required Imports	(4) 1933 Required Imports	(5) 1933 New Technology Required Imports	(6) New Technology Required Import Ratio
AF	67	.00609	42.5	67	24.5	.00243
AL	40	.00648	26.8	40	13.2	.00243
EP	--	--	--	--	--	--
PG	320	.02131	245.4	619	373.6	.02355
CG	58	.00811	44.7	112	67.3	.00852
TC	--	--	--	--	--	--
CO	--	--	--	--	--	--
HO	--	--	--	--	--	--
TD	--	--	--	--	--	--
GS	--	--	--	--	--	--

(1) in millions of rubles

(2) = (1) ÷ 1928 Gross Value of Output (Table 13a), KAPROST m^0.

(3) = (2) x 1933 Old Technology Gross Value of Output (Table 13c) in millions of rubles

(4) in millions of rubles

(5) = (4) - (3) in mullions of rubles.

(6) = (5) ÷ 1933 New Technology Gross Value of Output (Table 13e), KAPROST m^N.

Table 15

Inventory Ratios

Sector	(1) 1928 Deliveries to Inventory	(2) Old Technology Inventory Ratios	(3) 1933 Old Technology Deliveries to Inventory	(4) 1933 Deliveries to Inventory	(5) 1933 New Technology Deliveries to Inventory	(6) New Technology Inventory Ratios
AF	206	.01872	130.6	309	178.3	.01768
AL	--	--	--	--	--	--
EP	--	--	--	--	--	--
PG	80	.00545	61.3	350	288.7	.01820
CG	234	.03272	180.2	1564	1383.8	.17523
TC	--	--	--	--	--	--
CO	515	.13246	305.1	1819	1513.9	.13253
HO	--	--	--	--	--	--
TC	--	--	--	--	--	--
GS	--	--	--	--	--	--

(1) in millions of rubles

(2) = (1) ÷ 1928 Gross Value of Output (Table 13a), KAPROST s^{0}

(3) = (2) x 1933 Old Technology Gross Value of Output (Table 13c) in millions of rubles.

(4) in millions of rubles

(5) = (4) - (3) in millions of rubles

(6) = (5) ÷ 1933 New Technology Gross Value of Output (Table 13e) in millions of rubles, KAPROST s^{N}

Table 16

Output-Labor Ratios

(1) 1928 Labor Force	(2) One-Year Old Technology Output-Labor Ratio	(3) Two-Year Old Technology Output-Labor Ratio	(4) 1933 Old Technology Labor Force	(5) 1933 Labor Force	(6) 1933 New Technology Labor Force	(7) One-Year New Technology Output-Labor Ratio	(8) Two-Year New Technology Output-Labor Ratio
34770	.31642	.63284	22058	41310	19252	.52386	1.04771
3810	1.61995	3.23990	2555	4700	2145	2.53532	5.07063
19	29.78947	59.57895	15	36	22	85.95789	171.91578
1767	8.30447	16.60894	1355	2754	1399	11.34034	22.68068
3894	1.83667	3.67334	2999	4767	1768	4.46612	8.93225
1410	1.46241	2.92482	1175	1545	370	4.21836	8.43672
1255	3.09801	6.19602	744	2097	1354	8.43960	16.87920
754	2.24668	4.49337	618	868	250	4.69041	9.38082
1065	2.65258	5.30516	831	1357	526	7.13280	14.26560
2215	1.33363	2.66727	1918	2754	836	4.06658	8.13315

.) in thousands

!) = 1928 Old Technology Gross Value of Output (Table 13a) ÷ (1).

3) = 2.0 x (2) , KAPROST λ^o

) = (2) x 1933 Old Technology Gross Value of Output (Table 13c) in thousands

) in thousands

) = (5) - (4)

') = 1933 New Technology Gross Value of Output (TAble 13e) ÷ (6)

3) = 2.0 x (7) , KAPROST λ^n

Table 17

Output-Capital Ratios

	(1) 1928 Capital Stock	(2) One-Year Old Technology Output-Capital Ratio	(3) Two-Year Old Technology Output-Capital Ratio	(4) 1933 Old Technology Capital Stock	(5) 1933 Capital Stock	(6) 1933 New Technology Capital Stock	(7) One-Year New Technology Output-Capital Ratio	(8) Two-Y Ne Techno Outpu Capit Rati
F	8224	1.338	2.676	5217	11600	6383	1.580	3.160
L	7594	.813	1.625	5093	10151	5058	1.075	2.150
P	600	.94333	1.88666	458	3191	2733	.67563	1.35126
G	3017	4.86377	9.72754	2314	9754	7440	2.13217	4.26434
G	2618	2.73186	5.46371	2016	4867	2851	2.76991	5.53981
C	11366	.18142	.36284	9472	18273	8801	.17732	.35464
O	595	6.53445	13.06891	353	2100	1748	6.53677	13.07353
O	22982	.07371	.14742	18837	28507	9670	.12125	.24250
D	487	5.80082	11.60164	380	2318	1938	1.93746	3.87492
S	5680	.52007	1.04014	2558	10088	7530	.45157	.90313

1) in millions of rubles

2) = 1928 Gross Value of Output (Table 13a) ÷ (1).

3) = 2.0 x (2) , KAPROST b^o

4) = (2) x 1933 Old Technology Gross Value of Output

(Table 13c) , in millions of rubles

5) in millions of rubles

6) = (5) - (4)

7) = 1933 New Technology Gross Value of Output (Table 13e) ÷ (6)

8) = 2.0 x (7) , KAPROST b^n

Appendix D: Programming and Computer Solution of the Model

The model described in Appendix B is an optimization model with linear objective function and linear constraints, that is, it is a linear programming model. We chose to use the IBM Mathematical Programming System (MPS) to solve the model, both for reasons of availability and because it is one of the most common linear programming packages in use. Our model was solved successfully by MPS on an IBM 360 Model 44 with 256 K of main storage. For a detailed description of MPS please refer to the IBM publications listed at the end of this appendix.

Use of MPS requires that all of the linear relations be formatted in the MPS input language. A glance at the reduced form of the model (Appendix B, Table 6) shows that the form of most relations is very regular, with entries varying by industrial sector, time period or both. Further, even with the economies in the reduced form description, the model still has over 300 constraints and over 600 variables, which would require a considerable amount of keypunching to produce input acceptable to MPS. If this task were performed only once, the direct keypunch approach would be feasible. However, our research task required that we be able to vary parameter values quite often, and re-keying changes would have been intolerable.

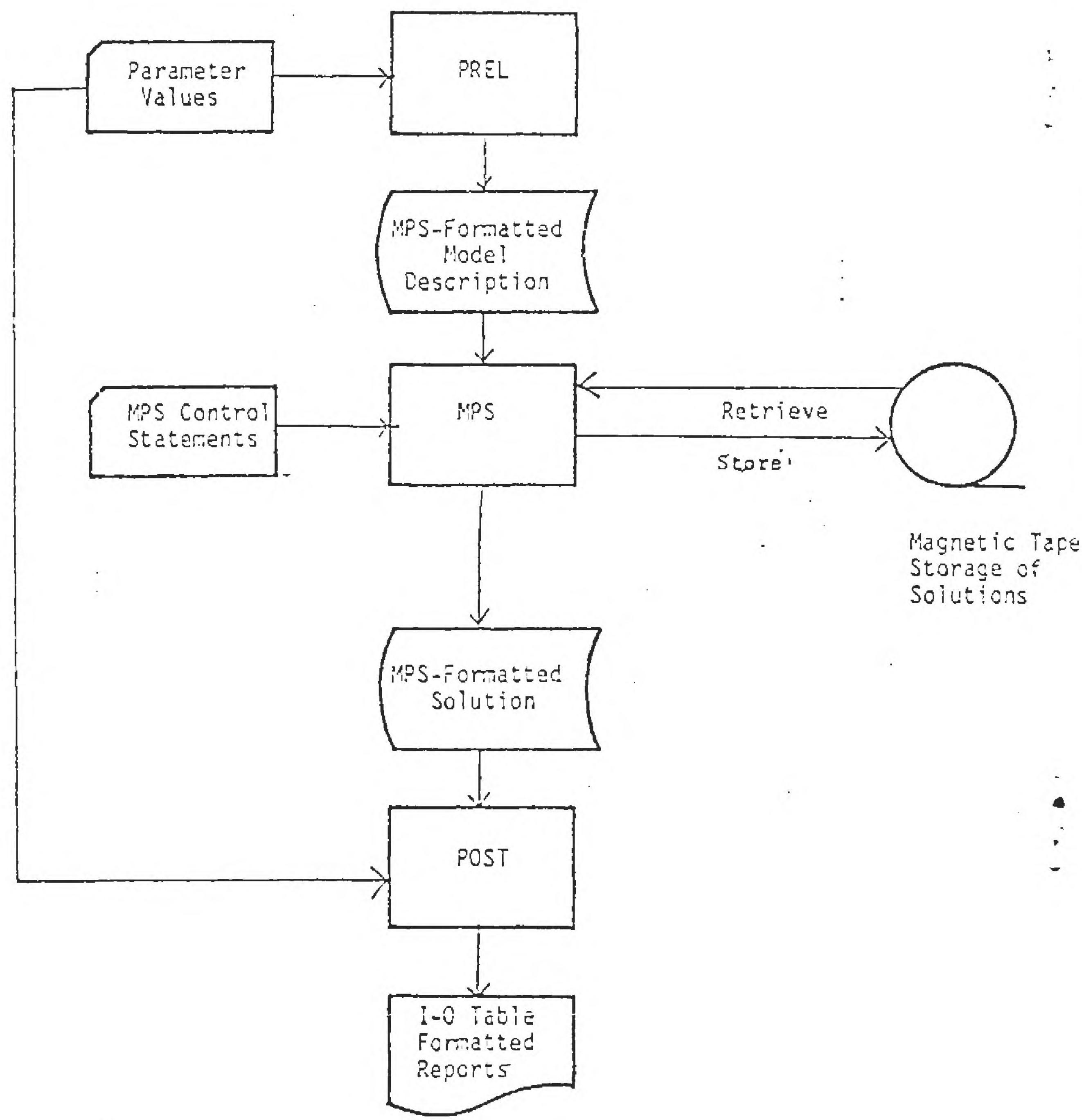
The regularity of the model, therefore, proved to be a blessing in disguise, because it permitted us to write computer program which would accept the parameters of the model as data, and then automatically generate the appropriate input to MPS. This preliminary processing program, or PREL, was written in the PL/I programming language, a choice dictated by the need for character manipulation capabilities. PREL is highly idiosyncratic in that it produces MPS input for only one model, KAPROST. For that reason we do not describe it in detail (though a copy can be provided on request). However,

the use of this technique may be of interest to other researchers as a significant time and labor saving device. For example, to raise capital productivity for all sectors would require re-punching 120 cards, if the MPS input were manipulated directly. Using PREL this can be done by altering two cards!

The solution obtained by MPS can be printed only in a rather crude form: a list of variable names and data values. The economic theory behind our work allows these solution values to be organized in the much more detailed manner of input-output tables with inter-industry, final demand and value added sectors. We felt it would be very useful in understanding the solution if the data were displayed in this form. A post solution program, POST, was written to take the output from MPS and reformat it in an economically meaningful way. POST, in addition, explodes the solution variable values, which correspond to the reduced form of the model, back to the complete set of variables used in the structural form of the model (Appendix B, Table 5). Like PREL, POST can only be used for our particular model, but the idea is valuable. POST was also written in the PL/I language and a copy can be provided upon request.

Figure 1 presents a flow diagram of our computer solution process. The parameter values, described in Appendix A, are keypunched and the cards used as input to PREL. PREL produces an MPS-formulated Model Description which is accepted by MPS, in addition to a card-deck of MPS control statements. As some need was felt for retaining different solutions in computer-readable form--one, in particular, being the savings which obtain from starting the solution process from a previous set of solution values rather than from scratch--a magnetic tape serves as a long-term storage and retrieval medium. MPS solves the model and produces a solution file, which is transformed by the POST program into economically meaningful reports. POST also requires the model parameters to produce the reports.

Figure 1/1


Parameter Values
PREL
MPS-Formatted Model Description
MPS Control Statements
MPS
Retrieve
Store
Magnetic Tape Storage of Solutions
MPS-Formatted Solution
POST
I-O Table Formatted Reports